SCHAFMAYER

Recent Paving Practice in Chicago

Civil Engineering

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BY

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Recent Paving Practice in Chicago

BE ACCEPTED AS FULFILLING THIS PART ON THE REQUIREMENTS FOR THE

PROFESSIONAL DEGREE OF Civil Engineer

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I. INTRODUCTION.

(I) Preliminary.

Controversies and discussions frequently arise over the practice followed in regard to pavement construction in various cities. Charges are often made of unfair requirements being incorporated in paving contracts by the officials in charge. These requirements are alleged to be drawn to discriminate against some paving interests or materials and in favor of some others. It is commonly reported at the present time that the Interstate Commerce Commission of the United States is conducting an investigation of conditions affecting certain interests in several cities of this country. This investigation is reported to have been instituted as a result of charges of unfair discrimination in favor of these interests. Such charges or statements are frequently encountered. Some may be justified, others may be for political effect, and many are entirely the result of ignorance and are absolutely unfounded. A few years ago a statement was given considerable publicity that the specifications for cresote oil which were adopted by the Board of Local Improvements of the City of Chicago, discriminated unfairly in favor of a monopoly. After a thorough investigation this statement was shown to be without foundation in fact. As a general rule, however, the Board of Local Improvements of Chicago has been remarkably free from any such accusations and controversies, and it is not now involved in the present one previously mentioned. On the contrary its practice has been very broad and impartial, and the requirements for materials and construction for pavements, have been as broad and comprehensive as
was consistent with good construction and the proper safe guarding of the interests of the property owners. Chicago has acquired a very creditable reputation in this respect among the engineers of many cities and towns of this country, and inquiries are being constantly received by the Board requesting information upon some phase of paving practice in this city. Often these inquiries are for information concerning methods and experience in this city with certain types of pavement and with certain details of construction. In addition many engineers and public officials visit Chicago and consult with the chief engineer of streets or his subordinates as to some of the details of paving practice. One of the principal reasons for Chicago's situation in this respect is that, because of the enormous amount of pavement being constructed here each year, and the many different kinds used, an opportunity is offered for broad experience with an unusually great variety of conditions.

In consideration of these facts the writer has prepared the following discussion with the object of presenting some of the principal items of interest regarding the recent paving practice in Chicago, under the supervision of the Board of Local Improvements.

(2) Scope of Discussion.

This discussion is intended to present information concerning pavements built, and the organization and methods used in their construction, by the Board of Local Improvements of the City of Chicago. There are several other organizations in Chicago, such as the different park boards, that build considerable
quantities of pavements. Their work however is not included in this article which is confined to the practice of the Street Pavement Division of the Bureau of Construction of the Board of Local Improvements. It is intended to be further confined to the engineering features of this division as much as possible. It is desirable, though, because of the intimate relations between the engineering phases and some of the routine steps of pavement proceedings, that some of these legal or routine steps be considered. They will therefore be discussed briefly in their regular order. Where practicable a few examples of the records and forms used in connection with the engineering activities will be shown. Forms and records in use by the clerical and accounting forces are not considered. In explaining the features of interest as to the pavements built it is desired to show the essential requirements and standard practices of construction without entering into a mere recital of specifications. In certain cases, however, considerable latitude is allowed to the contractor as to using optional materials. For this reason the specifications are very comprehensive in stating the requirements for each class of material allowed. In such cases an attempt has been made to present briefly the important essentials according to the specifications. An example of such conditions may be found under the heading of 'Asphalt Pavements'. The subject matter has been divided under the four general headings of 'Organization', 'Routine of Paving Proceedings', 'Records and Forms', and 'Types of Pavement Construction'.
(3) Acknowledgement.

In securing information for this article the writer was aided by several of his friends and associates as follows:

Mr. J. L. Jacobs, engineering expert of efficiency for the Civil Service Commission, presented the chart on organization shown as Plate I and explained certain details of organization.

Mr. C. D. Hill, engineer of the Board, kindly permitted the use of tracings for the tables for partial estimates shown as Plates 2 and 3. Mr. John E. Wittell, chief engineer of streets, permitted the copying of the report and index cards shown as Plates 4, 5, 7, and 8, and offered many valuable suggestions. Mr. Julius C. Gabelman, assistant chief engineer of streets, furnished a copy of the instructions to inspectors, and the efficiency card, a copy of which appears as Plate 8, and aided by helpful advise in obtaining and selecting material for the subject matter. Mr. Peter Matthews of the cement laboratory furnished the cement report blanks for Plates 9 and 10. Mr. W. F. Harvey, engineer in charge of the inspection of creosoted wool block manufacture, contributed the creosoted block report blanks for Plate 11, and offered information as to the details of treatment. Mr. E. N. Eaton, chief chemist in charge of the asphalt laboratory, presented the asphalt reports, copies of which may be seen on Plate 12, and gave information as to details of inspection and analysis. Mr. Oscar Brown, of the maintenance and repair section, presented the blank form for Plate 13. Mr. Robert Gilmore, also of the repair section, contributed the blanks for Plate 14.

The writer hereby desires to acknowledge his indebtedness
Entries on this chart are based on the appropriation ordinance for the year 1913, passed by the City Council Jan. 2, 1913, and amended Jan. 8, 1913.

Number of positions and salary total appropriated for positions indicates by lines to the left and right of the line of authority.

Provided for in blanket items, number of year employees is not indicated. Blanket salary appropriation for emergency services follows the amount specifically appropriated.

EFFICIENCY DIVISION-CIVIL SERVICE COMMISSION—CITY OF CHICAGO.

PLATE 1.
to these gentlemen for material or assistance in the preparation of this discussion and to express his appreciation of the courtesy and kindness with which such assistance was rendered.

II. ORGANIZATION.

(1) A division of the Bureau of Construction of the Board of Local Improvements.

The Board of Local Improvements of the City of Chicago is organized in accordance with a law of the State of Illinois entitled, "An Act Concerning Local Improvements", approved June 14, 1897, and in force July 1, 1897, and with amendments which have been added to it from time to time. This Board consists of a president, four members, and the superintendent of special assessments, who is ex-officio secretary of the Board of Local Improvements.

Under the local improvement law this Board has general supervision over all improvements built under the authority conferred by this law, within the City of Chicago. The work of the Board is performed very largely by two bureaus, the bureau of special assessments and the bureau of construction.

The special assessment bureau which is in the jurisdiction of the superintendent of special assessments, consists of the general office which has charge of the Board records and files, the accounting division, and the special assessment division which performs the clerical work involved in the preparation of resolutions, notices, ordinances, etc., and of spreading the assessments of the cost of proposed improvements over the various parcels of property to be benefitted.
The bureau of construction, under the supervision of the engineer of the Board, consists of three divisions. They are the sidewalk division, the sewer division and the street paving division. The sidewalk division, under the direction of the superintendent of sidewalks, has charge of the construction of all sidewalks. The engineer of the Board has immediate charge of the sewer division, which carries on the construction of sewers. The pavements laid by the Board of Local Improvements are built under the supervision of the street paving division which is under the direction of the chief engineer of streets. A chart showing the general organization of the Board of Local Improvements as based on the budget for 1913 is inserted as Plate 1.

(2) Staff under the Chief Engineer of Streets.

(a) Engineers.

The chief engineer of streets aided by the assistant chief engineer, supervises all the work of pavement design and construction. For purposes of convenience the city is divided into six engineering divisions, (the number of divisions has been increased to seven this year), with a division engineer in charge of each division or district. Each division engineer is assisted by a junior engineer and one or more rodmen as circumstances may require. This makes a regular working force of 22 engineers, including the chief engineer, who in the past have performed the engineering operations necessary to pave the streets and alleys that have been improved by the Board of Local Improvements.
(b) Inspectors.

To insure that the pavement shall be built according to contract and specifications, the engineering staff is supplemented by the inspection staff which consists of 95 paving inspectors, and 6 general inspectors. The general inspectors visit the different improvements in cooperation with the division engineer and have charge of the paving inspectors, and keep their time. One general inspector has charge of all repairs during the guarantee period. One has charge of the inspection of all granite block pavements under construction, and the others have charge of the inspection of all the new pavement under construction except granite, in their respective districts. They are given assistants during the busy season as may be required. Also during the times of greatest paving activity when the regular inspector's eligible list becomes exhausted, extra inspectors are appointed as becomes necessary; in 1913 there were 27 extra men required.

(c) Asphalt, Brick and Cement Laboratories.

Because of the enormous quantities of asphalt and asphaltic pavements laid in Chicago the Board of Local Improvements maintains its own asphalt laboratory. This laboratory is directed by an expert asphalt chemist who reports to the chief or assistant chief engineer of streets. In this laboratory tests are made of the various bituminous materials and mixtures entering into the composition of the different types of pavements. The laboratory staff also supervises the preparation of these mixtures at the plant, by placing inspectors at the various plants where mixtures are being prepared. In carrying on this branch of the work of pavement construction the asphalt chemist is aided by an assistant
engineering chemist, 4 asphalt inspectors in charge and asphalt inspectors as needed.

The bricks used in paving improvements are also tested by the Board of Local Improvements in its own testing laboratory. This is done by a paving brick tester who reports to the chief engineer or his assistant.

Similarly cement used for pavements is tested by the Board in its cement laboratory under the direction of a cement tester who also reports to the chief or assistant chief engineer. The cement tester is aided by 7 assistants during the busy season in sampling, testing and shipping the cement used on the various contracts.

(d) Repairs During Reserve.

The repairs during reserve are made under the field supervision of the general inspector in charge of repairs. The records of all permits for street openings and their repairs are kept in a very comprehensive set of books and records in the care of one of the clerks, assisted when necessary by other clerks and by paving inspectors who are in the office awaiting assignment.

(e) Clerks.

The chief engineer is aided in the clerical work of his office by a stenographer, a chief clerk, a senior voucher clerk and a junior clerk, in addition to the clerk in charge of the records of repairs and maintenance.
III. ROUTINE OF PAVING PROCEEDINGS.

(1) Origin.

According to the special assessment law of the State of Illinois under section 7, all proceedings for local improvements to be paid for by special assessment shall originate with the Board of Local Improvements. The attention of the Board however, is usually gained in one of three general ways, viz., by the alderman through a council order, by petition, or by action of any member of the Board through the proper committee. When a proposition is thus brought up it is first referred to the chief engineer of streets for a report and recommendation, before official action is taken by the Board.

(2) Engineer’s Report.

When the question of a pavement improvement is referred to the chief engineer of streets for a report and recommendation he submits it to the division engineer of the division in which the proposed improvement is to be located, who investigates the conditions and writes the report. In this report is given the information as to whether the street has ever been paved or not, and if paved, the kind of material used in the old pavement, the present condition, and the width of the old roadway. Unless the original council order or petition to the Board specifies a satisfactory roadway width, it is customary for the engineer to recommend the width of the proposed roadway.

(a) Width.

In determining upon the desirable width for the proposed roadway the division engineer usually considers the economic, structural and traffic conditions. For purposes of economy it has
been the practice in Chicago for several years to reduce the width of the roadways of pavements in repaving residence streets wherever such reduction has been found advantageous. In paving residence streets that have never been improved the same principle of recommending narrow roadways as compared to those of several years ago is followed. The principal advantage of the narrow roadway is that of economy in first cost. The usual roadway on a 66 foot street in Chicago was formerly 38 feet. The width in most common use now on the average residence streets is 30 feet. This alone effects a saving in first cost of 4 square feet or almost one half a square yard of pavement per lineal foot of frontage on each side not counting the saving in excavation. The narrower roadway also effects an economy in cleaning as it reduces the area to be cleaned. From the standpoint of maintenance the advantage of the narrow roadway depends chiefly on the material. To a certain extent the cost of maintenance varies with the density of the traffic. With certain paving materials, however, such as sheet asphalt or creosoted wood blocks the pavement needs a moderate amount of traffic to keep it in its best condition. Consequently on residence streets with only a light local traffic portions of the pavement on a wide roadway would deteriorate from lack of sufficient traffic, while if a narrow roadway were used the entire pavement would receive enough traffic to keep it in condition and aid in its maintenance. For these reasons many roadways have been narrowed when the streets were repaved. Old roadways of 50 feet in width have been cut down to 38 feet and 34 feet. Old 38 feet roadways have been reduced to 32, 30, and 28 feet, and many pavements have been built with roadway widths of 26 and 24 feet.
While the general tendency has been to reduce the width of roadways on residence streets it has been somewhat the reverse on streets with car tracks. In this case the usual roadway width on a 66 foot street was formerly 38 feet between curbs leaving about 11 feet on each side of the street cars. Now, however, since the introduction of the large modern street cars and the advent of the mammoth motor trucks, the minimum width recommended is usually 42 feet and greater widths are very often recommended, depending on the width of the street, the traffic and local conditions.

(b) Drainage.

The report of the engineer to the Board of Local Improvements on the proposed paving of a street merely states in regard to drainage, whether or not there is a sewer in the street, and if so, between what limits. If no sewer is in the street the report states whether or not one is needed. In deciding upon the necessity for a sewer the surface drainage, the location of summits in the gutters and of catch basins with their inlets is considered, but only in general, no detailed design being worked up. The nature of the frontage is also considered. The usual city block in Chicago is approximately 600 feet long by about 265 feet wide. The lots usually face the longer sides of the block and either already require or will require a sewer in the long block to serve them in the future for sanitary purposes. In such streets sewers are usually built before the paving proceedings are commenced. If the sewer is not in, however, the report states that a sewer will be necessary prior to the construction of a pavement. If the property is improved or becoming active and if a trunk sewer is
available for an outlet, the report also recommends the institution of proceedings to build the sewer. If such is not the case the report includes a recommendation to file the proceedings, which is equivalent to a recommendation against paving at the present time.

In streets running along the short ends of the blocks it is often the case that no sewers are built. If the block has been subdivided in such a manner that part of the lots front on these streets, provision for a sewer to serve these lots must be made. Frequently, however, all the lots face the longer sides of the block and present only side frontage to the streets running along the ends. The question then becomes one of merely taking care of the drainage from the pavement. In such cases it is often possible to drain to basins at or near the intersection of the cross street and thus avoid the cost of a sewer.

The underdrainage rarely enters into consideration as a determining factor as to the necessity for a sewer before paving. The reason for this is that before a pavement is needed there will usually be so many sewers in the streets of the neighborhood and so many basements along the line of the proposed improvement which drain into these sewers that the water table is greatly lowered and the subgrade is already thoroughly drained.

(c) Foundation.

Only two types of foundation course for pavements are used generally in Chicago. They are concrete and rolled macadam of either stone or slag. The rolled macadam foundation is used generally with the asphaltic macadam pavement and occasionally with the sheet asphalt and asphaltic concrete surfaces. The rolled foundation is usually eight inches thick when built entirely new.
Sometimes, however, when an old water bound macadam pavement is in fairly good condition and can be utilized it is repaired and dressed up or reshaped and used as a foundation for an asphalt or an asphaltic pavement. The concrete foundation is usually laid with a thickness of six inches, although, on some light traffic streets, a five inch concrete course is sometimes used, and on streets with extremely heavy traffic, an 8 inch concrete course has been used. The 6 inch Portland cement concrete foundation is the usual one with all the types of block paving and the asphalt and asphaltic concrete. The macadam or rolled foundation is usual with the asphaltic macadam although the concrete foundation has been used with this type. When reporting on a pavement if the engineer proposes to use any other than the customary foundation for it, he includes such facts in his report.

(d) Extent.

One of the details of a proposed improvement which it is necessary to consider in the engineer's report, is that of the limits between which the pavement shall extend. According to the Local Improvements Law previously mentioned the Board of Local Improvements, only, has power to order an improvement to be paid for by special assessment. This necessarily carries the power of fixing the limits. It often occurs that improvements are requested or reports are ordered on proposed pavements, that overlap some existing or pending improvement. In other cases it may be that a street is not open the entire distance or that the improvement should be extended a block or two farther at one end to connect to some existing pavement. These conditions and special conditions affecting the limits are considered by the engineer, and
satisfactory limits are recommended to the Board for its adoption.

(e) Material, Car tracks.

Many petitions and council orders are submitted to the Board that do not specify the material desired for a pavement. Some that are presented request an unsatisfactory or impractical paving material. In other cases more than one petition or request is received by the Board each asking for a different material. The engineer in such cases includes in his report a recommendation as to the material he advises for adoption. In arriving at a decision as to which material to recommend he takes into consideration all the information that is available regarding the street. Some of the chief factors considered are: the nature and amount of traffic and its probable increase. The character of the neighborhood whether residential, industrial, mercantile or of the office building type. The value of the property in the vicinity and the relative first cost of the different paving materials. The local sentiment along the street so far as known. The availability of some paving material near by. The kind of pavement already laid on, or contemplated for adjoining portions of the same street or intersecting and adjacent streets, and whether or not there are street car tracks on the street. In addition the relative standing of the different materials according to the theory of pavements, as described in standard texts on paving such as Baker's, "Roads and Pavements", or Tillson's, "Pavements and Paving Materials", is considered as applied to the particular street in question.

The nature and amount of the traffic is considered in conjunction with its probable increase. In the case of new subdivisions it often happens that at the time paving proceedings are
commenced, there are no traces of any improvements or traffic, nothing but vacant prairie dotted with subdivision stakes. But simultaneously with the building of the pavement many other improvements are built, and houses and flat buildings are being constructed in various parts of the subdivision. It thus happens that the moment a portion of the new pavement is opened for traffic it receives a large amount of heavy teaming and trucking of material for additional improvements.

The character of the neighborhood affects the weight given to the various qualities possessed by the different paving materials. For instance, in a purely residential district the sanitary and general acceptability qualities are given a greater relative importance or weight than the economic qualities of durability and low maintenance cost. In an industrial district the economic qualities of durability, low maintenance cost, ease of traction and good foot hold are among those of chief importance. In a mercantile or office building district, the factor of noiselessness would probably govern the selection to a great extent.

The value of the property and the relative first cost of the pavement, govern the selection of a suitable paving material to the extent that no pavement should be chosen whose first cost is so great that it places an unreasonable burden upon the property or is greater than the probable benefits to accrue to the property from the improvement.

Where the local sentiment on a street favors one material among two or three kinds almost equally well adapted to the street, this sentiment usually governs.

The availability of local material is exemplified in
the case of many streets near the steel works in the southern part of the city, where slag for a macadam foundation is readily obtained at economical rates.

The kind of pavements already laid in a vicinity is considered from a standpoint of harmony in order to avoid too much of a crazy quilt effect in pavements; and also because they give an indication from their condition and the criticism or commendation they receive, as to what may be expected of the new pavement if built of the same material.

The fact as to whether car tracks are on the street or not is considered because some pavements, such as macadam for instance, are not adapted to car track streets. Another point in regard to car tracks which receives consideration in the engineer's report is whether or not the tracks have been rehabilitated recently. It is one of the policies of the Board of Local Improvements not to lay a new pavement on a street with car tracks until they are rebuilt and placed in first class condition according to the traction ordinances of 1907. If this has not been done the company owning the tracks is informed of the paving proceedings. The railway company then attempts to arrange its construction program so as to have their tracks rebuilt in time for the paving construction. If it fails to do so, however, the pavement construction is delayed until the tracks are rebuilt.
(3) Estimate Ordered.

The report of the division engineer is transmitted to the Board by the chief engineer who approves it with such modifications or additions as he may care to make. The Board, of course, takes such action as it sees fit. If the report has been favorable, though, the usual course is to order an estimate for the improvement according to the recommendation of the engineer. This order is endorsed on the report and returned to the engineer for an estimate. Upon receipt of this order the chief engineer then orders a plat of the street from the bureau of maps and plats, of the Department of Public Works, for the preparation of the estimate, and for spreading the assessment. This bureau then prepares a tracing of the street from the official atlases. A print is made of this tracing and the print is delivered to the engineers for field and office use, and the tracing is used later by the special assessment clerks in spreading the assessment. As may have been noticed under organization, there are no draftsmen in the paving division of the Board. All estimate plats are prepared by the draftsmen in the bureau of maps, upon requisition by the chief engineer. The only drafting done in the paving division is the preparation of the profiles, and special plats and designs, which are done by the engineers of the division.
(4) Preparation of Estimate.

(a) Field work, levels, checking plat and locating details.

After receiving plats for paving improvements the engineers in the various divisions proceed to do the field work necessary for the preparation of the preliminary estimate while the weather is favorable. This is done as far as possible by sandwiching it in among the various duties performed during the construction period. In this way the data for estimates are secured on as many improvements as possible. At the close of construction in the fall and the completion of final measurements and estimates, almost the entire time is devoted to field work. It is not practicable, though, to complete the field work on all of the proceedings ordered before the winter sets in. The remaining levels, surveys etc., are taken up and completed during the favorable periods throughout the winter.

Levels are run over the portion of a street which it is proposed to improve. Readings are taken on existing improvements such as sidewalks, old curbs, at intersections and at breaks in grade, and at any other points of particular notice. Surface readings are also taken as may be required for preparing a grading estimate. On many streets in Chicago the surface is so regular and uniform that one average surface reading is all that is necessary at each station. On other streets with irregular surfaces or side ditches etc., it is necessary to take complete cross sections.

At the time the levels are run the field survey is usually completed by checking the plat on the ground and locating
details. The information obtained is usually recorded in the form of notes and sketches made on the plat in the field. Some of the principal details so recorded are: the kind and condition of the old pavement and width of roadway if any; the kind of curbs and condition of same; the location, condition and type of covers on catch basins and manholes; the condition, width and the kind of pavements on intersecting roadways; the location of curb walls, etc.; any steam or street railway lines on or crossing the street; the location of the roadway with respect to the street line; and the exact limits of the proposed improvement and of any exceptions. Often this information can be readily sketched in and located by a few simple measurements or ties. In more complicated cases, however, it is necessary to make more elaborate surveys.

(b) Office work.

The preparation of plans and estimates is one of the chief occupations in the office of the street paving division of the Board during the winter months. A general plan or design of the street is laid out on the plat after it has been checked in the field. No profile is made as a general thing unless the improvement presents some unusual problem which requires more detailed study. Any proposed changes in the system of drainage are indicated by new catch basins shown approximately in their proposed locations. This tentative plan on the estimate plat gives ample information for estimating the cost of the ordinary paving improvement.

The estimates are made up on blank forms, consisting of a front or title sheet containing a summary of the estimate, and of inner sheets showing the items of the estimate in detail.
On the inner sheet is shown first the total frontage with its corresponding amounts of paving and curbing. Then under the intersections are shown the various intersections with the grades of the curbs, and the amount of paving, curbing etc., corresponding to each. The whole is footed up and recapitulated on the back sheet, and entered on the forms on the title sheet. On the title sheet are also given the limits and all exceptions described in detail, as well as the proposed plan of assessment, whether two, three, or five year, etc., the old roadway, the proposed roadway and any special notes as to alignment for use in drawing up the ordinance.

When streets on which car tracks are located are under proceedings for paving, the street railway company of course is informed of that fact. The usual case is that the car tracks are directly over the sewer which is along the center line of the street. It is very desirable, in order to prevent future settlement of the tracks, that all connections with the sewer be made at the time the tracks are being rebuilt, before paving. For this purpose plats are prepared by the paving engineers showing the portion of the street under consideration, and showing all new catch basins required, and their proposed location. These plats also show proposed wing sewers and any other changes in drainage for which connections to the sewer are to be provided by the Street Railway Company. The railway company then makes the connections at the time their tracks are rebuilt and extends them out to their right of way lines where they are blocked off and sealed. Then when the pavement is built later on, it is merely necessary to join any new basins to these connections and all cutting under
the car tracks is avoided.

(5) Public Hearings.

Upon receipt of the engineer's estimate the proper resolution is passed by the Board of Local Improvements, and the required notices of a public hearing are sent out to the interested property owners. The chief engineer of streets is usually present at all hearings on paving improvements and consults with the board members on technical questions. Previous to the time for the hearings, he submits copies of the notices of the hearings that are scheduled, to the division engineers. The engineers then check off the details as given in the notices of hearings on improvements in their respective divisions. If any errors are found or if, for any reason, some change is desirable, it is noted and recommended on the notice. The chief engineer takes these copies to the hearing and uses them to aid him in making recommendations for the proper disposal of the various projects.

(6) Ordinance and Assessment Roll.

After favorable action on a pavement proceeding at the public hearing an ordinance is prepared by clerks in the special assessment bureau, and sent to the city council for passage. After passage of the ordinance the assessment roll is made up and the assessment is spread by special assessment clerks. The preparation of the ordinance and spreading of the assessment both involve principally routine clerical work, and about the only duty
of the engineers in connection with them is to advise with the clerks as to any special or local conditions, or as to any particular factor affecting the spreading of the assessment.

(7) Confirmation of Roll.

When the assessment roll has been cast by the bureau of special assessments it is filed in court for confirmation. The details connected with these legal proceedings are handled by the law department of the Board, and no assistance is required of the engineers except in cases of contests. In such cases, if engineering features are involved, the engineers are called to consult with the lawyers as they may be required.

(8) Specifications.

As soon as assessment rolls are confirmed in court the chief engineer of streets is notified, and when a number of proceedings have accumulated in sufficient quantity to make up a letting, the specifications are prepared and the streets are advertised for bids.

(a) Uniform Features.

The specifications are prepared by the division engineers of the respective divisions. Printed forms are used in which blanks have been left for insertion of specific details. These printed forms are usually prepared at the beginning of a season under the supervision of the chief engineer. Those now in use conform in most respects to the recommendations of the Society for Standardizing
Paving Specifications, with such adaptations as tend to fit more closely into the special facilities and needs of Chicago.

The general clauses in the specifications such as "Instructions to Bidders", "Definitions", etc., are all uniform in each of the various sets of specifications. The clauses concerning sewer adjustment work such as adjusting old manholes and catch basins, and those for new covers are also alike for each kind of pavement. Those for curb and gutter are also standard clauses for each type of curbing. But since different types of curbing are used with a single kind of paving material, several optional curb clauses are included and when the engineer prepares the specifications for any particular contract, he retains the clauses which agree with the ordinance and eliminates the others. The clauses for concrete foundation and for mortar are also uniform, the only item in the foundation clause which varies being that of thickness or depth. The clauses governing the wearing surface vary with the material used. They are followed by uniform general clauses covering such details as headers, cross walks, cement walks, change of plans and extra work, connection of openings, patents, damages and obstructions, direction and superintendence, guarantee and manner of payment. Such clauses naturally are the same for all paving contracts and in such an office as that of the Board of Local Improvements, a great deal of time is saved, and much greater efficiency is obtained from the engineering staff, by having printed copies of specifications for each type of pavement used, with items for only special or local features to be inserted by the division engineer in charge of the work.
(b) Local Features.

Before completing the specifications for a proposed improvement the engineer goes over the street again, noting in detail the local features such as the condition of the catch basin and manhole covers, the probable number of gutter grates required, the sidewalks to be cut off or extended, whether or not there has been any material dumped in the street recently, and the existence of any trees or obstructions.

Many of the old cedar block pavements have antiquated wooden covers on the manholes and basins, and many other streets on which the sewer appurtenances are old have iron covers which are too light or which are cracked or otherwise defective. New covers are specified in all such cases. In cases where the roadway is to be widened or narrowed many catch basins will be out of the line of the new gutter. Hence grates will be needed and are included in the itemized list of quantities. An approximate estimate is made of new sidewalks required for extending existing walks to the new curbs, and prices are also received for this item. If there has been any recent filling done on the street since the previous grading estimate was made, new levels are run and a new grading estimate is made. The revised quantity is then substituted for the original grading item in the itemized list of quantities for bidders. The case of trees or other obstructions existing in the line of the improvement is usually mentioned in a special note which states the manner of paying for their removal. Such items are ordinarily included in the price bid per square yard for paving. Any other special or local feature is also taken care of at this time by inserting a particular note or clause.
concerning it in the specifications.

When the specifications are completed they are turned in to the chief engineer who checks them over with the assistant chief engineer before placing them on exhibition for the use of bidders in preparing their proposals. Bids are then received and the contracts are awarded by the Board of Local Improvements.

(9) Line and Grade.

(a) Streets.

The contractor to whom the contract for paving a street has been awarded, notifies the engineer of the district when he is ready to commence work, and requests that the lines and grades be given. All lines and grades are given by the engineer or his assistants. Grade marks are usually set two feet above curb grade on posts, fences, or walls of buildings. It is customary to give grade marks at each corner of an intersection and along the street at intervals of about 150 feet. Lines are generally run on an offset of some convenient distance such that the offset line comes upon the sidewalk. It is marked with crayon on the surface of the walk and cut in later with a chisel. Both lines and grades are given with an ordinary wye level except in cases of some curvature or of some peculiar conditions requiring the use of a transit. In some cases where a street is being paved in a new neighborhood not yet built up, it is necessary to place all marks for line and grade upon stakes at the sides. In general, however, a street is at least partially built up before paving proceedings are commenced. In addition to the line of the principal street in the contract
All wings at intersections are laid out on offsets and all exceptions as well as the extreme limits are marked when the line and grade is given. No other marks are given at this time for the guidance of the construction forces for the ordinary street pavement. These points establish the vertical and horizontal location of the curbs and practically all other dimensions for subsequent steps in the work are referred to the curbs. These references and further details of construction are given on a drawing. This drawing forms a sort of combined profile and detailed plan of the pavement and is called a "profile".

(b) Alleys.

When an alley is to be paved the lines and grades are given in very much the same manner as for streets. Marks are given both for the grade of the curbs and for that of the center line of the alley which is usually dished from 2 to 4 inches below the curbs. Grade marks are placed at the ends of the alleys, at all summits and at necessary intermediate points. Most alleys drain out to the streets and the fall necessary to carry the water is obtained by sloping the pavement up from one street to a summit and down again to the next street. The depression of the center line below the curbs is practically constant for an alley of uniform width so that these marks are all that are necessary to locate the grade of the pavement. The line is run down the alley on an offset and marks are given at each end and if it is a long alley, additional marks are given on convenient offsets at accessible points between. This gives all the points essential to the proper construction of the pavement and no grade sheets or profiles are necessary for an alley pavement.
(10) Profiles.

The so-called profiles as used on pavement construction in the Board of Local Improvements, are not real profiles according to the usual meaning of the word, 'profile', as applied to engineering operations. The ordinary engineering profiles are not used here for street pavements except in particular cases such as where large side ditches exist or where varying slopes of considerable pitch occur. But these conditions are rarely found in Chicago, as most of the streets are either level or on a very easy gradient. The profile as commonly used here, is a sort of a composite of a detailed design, working plan or grade sheet and profile combined. It consists essentially of an outline drawing showing the curbs as it is proposed to build them. Catch basins are shown in their relative positions by small circles like those used to designate rivets on a bridge or structural drawing.

(a) Location of Catch Basins.

It is customary in Chicago to construct several catch basins to the block at the time a new sewer is built. The most common practice has been to build four basins at each intersection with an additional pair at the middle of an ordinary 600 foot block, and with no intermediate basins in an ordinary 266 foot block. This distribution gives perhaps the most satisfactory location for basins. It furnishes ample drainage at the street intersections, thus aiding in keeping foot crossings passable, and gives a distance between basins on either street of from 300 to 320 feet. Basins so located can also be easily adapted to the design of the pavement which is usually built several years after
the sewer is finished. When the street is paved one of the common plans for location of basins on streets with a level grade is that of adding two pairs of basins to each long block about 200 feet each way from the existing pair at the middle of the block, or about 100 feet from the nearest street line of the intersecting street, and 115 to 140 feet from the basins at the intersections. On short blocks often one additional pair of basins is provided near the middle of the block or approximately 150 feet between basins. On streets with a sloping grade the additional basins are placed nearer the lower intersection and farther from the higher one depending upon the difference in elevation. Where the length of blocks differs from the ordinary length or where other conditions are encountered, different spacing of basins is necessary suitable to the particular condition.

(b) Location of Summits.

The streets in Chicago have very little longitudinal slope as a general rule and many of them run at a level grade for considerable distances. Hence to obtain a fall in the gutters sufficient for drainage purposes the depth of the gutters below the top of the curb is decreased from the basins to summits placed at intermediate points. This is considered preferable to the other expedient of springing a summit in the entire pavement and curb, as is done in alleys, and carrying the gutters a uniform distance below the curb grade. Most of the new pavements in Chicago have a concrete combined curb and gutter which lends itself very readily to the method of varying the depth of the gutter below the top of the curb. The cases in which a gutter is formed in the pavement adjoining a vertical curb can also be handled very easily in this
way, although it is more difficult to obtain a true slope in the gutter when it is formed in the pavement than when a concrete gutter is built. The pavements built in Chicago in recent years have been designed to avoid deep gutters and steps at cross walk intersections. Instead a summit is placed at each cross walk with just enough dish in the gutter to contain the water. The gutter then slopes down to a shallow inlet at the catch basin at the curb corner. In the other direction it descends to the catch basin located from 100 to 125 feet along the block as indicated under, 'Location of Catch Basins'. This design eliminates the step at the curb and produces a clean dry crossing.

The standard gutter slope used by the engineers of the Board of Local Improvements is $0.5\%$, or 6 inches fall in 100 feet. Most pavements built by the Board approximate this slope in the gutters although it is necessary at times to deviate from it more or less. The location of the summit between the basins depends upon the difference in elevation of the inlets and on the gutter slopes. If these slopes are equal and the inlets are at the same elevation the summit will naturally come half way between inlets. If one inlet is higher than the other the summit will be nearer the high inlet. An example of this would occur in a case of 2 inlets 150 feet apart one being 0.2 of a foot above the other and proposed gutter slopes of $0.4\%$ each way from the summit. The difference in elevation of the inlets would be overcome in the gutter leading from the lower inlet in just 50 feet. At this distance up the slope then, the gutter there would be exactly level with the upper inlet and the summit would be half way from this point to the upper inlet, or 50 feet from the upper and 100 feet from the lower
inlet. This method can be applied to practically any case that may occur in pavement design. The paving engineers in the Board of Local Improvements, however, for several years have been using a more simple and rapid method of determining the location of summits when making the detailed design of a pavement in preparation of the profile. It is based on the following calculations:

The sketch below shows the elevation of a gutter adjoining a curb between two catch basins. Let the top of the curb be represented by the line CD and the two inlets at the basins by A and B, which differ a known distance H in elevation. Let AE and BE represent the gutter sloping both ways from the summit E whose location is desired. Let x be the distance from E to the higher inlet, and L the distance between inlets. Then L - x represents the distance from E to B. Then let s be the slope of the gutters in per cent, and from the sketch we obtain the equation sx equals s(L - x) - H. Since s is in per cent or hundredths of a foot let H also be taken in hundredths of a foot. The equation becomes sx equals sL - sx - H, or 2sx equals sL - H, and x equals (sL - H)/2s. Now since it is customary here to use a slope of 0.5%, the denominator, 2s, becomes 1/2 and x equals 0.5L - H or L/2 - H. The vertical distance H, it must be remembered, is taken in hundredths of a foot.
Let us apply this formula to the previous example. Since the slope was given as 0.4\% we must take the general formula $x$ equals $(sL-H)/2s$ which becomes on substituting, $x$ equals $(0.4\times150-20)/0.8$, which equals 50 feet. But for this slope the formula gives no shorter method than the one first described. It is when a slope of 0.5\% is used that the method is shortened. Take the same example but use a 0.5\% slope instead of 0.4\%, and we can apply the formula $x$ equals $L/2-H$, or $x$ equals $150/2-20$, then $x$ equals 75-20 equals 55.

As may be seen this method merely involves the work of dividing the horizontal distance between inlets in two and subtracting the vertical distance between inlets in hundredths of feet, from this half distance to obtain the distance from the summit to the upper inlet. The sum of the distances $K$, equal to $sx$, and $N$, equal to the length $x$ multiplied by the longitudinal slope of the top of the curbs, when subtracted from the height of the curb at $A$, (shown as AC on the diagram), gives the depth of curb $Y$ at the summit $E$. This depth is shown in inches at its proposed location on the profile. Of course the summit must come below the top of the curb and is seldom made less than 3 inches below it. The desired depth below the top of the curb can be obtained by altering the depths $AC$, or $BD$, of the inlets below the top of the curb, or by varying the distance $L$, between catch basins, or by using a different slope $s$, in the gutters. When the various distances or dimensions are decided upon they are marked in their relative positions upon the profile. This analytical method is most commonly used in pavement design in this office although some of the engineers also use the graphical method at times. It consists of
drawing the profile of the pavement to scale on standard profile paper and locating the summits by scale. This method is slower than the analytical one, especially when skilled judgment is used in the spacing of basins and inlets and in deciding on depths below the top of the curbs.

(c) Crown.

Theoretically the crown of most pavements laid by the Board of Local Improvements is to be at curb grade but, except on car track streets where it meets the tracks, it usually undulates up and down along the street from summits to inlets. If the crown were uniform these undulations would be parallel to the gutters. This would seriously mar the appearance of the street and would be more or less objectionable for traffic. The long lines that contribute so much to the beauty of the street are obtained to a certain extent in spite of the breaks in the gutters, by decreasing the crown from the inlets to the summits. This gives to the finished pavement a sweeping longitudinal curvature, or a sort of modified prairie like effect that is pleasing to the eye and relieves the monotonous appearance of a pavement with a uniform crown and uniform height of curb. At the same time the choppy saw tooth effect is avoided if the proper combination of dimensions has been used in the design. Of course since the Board of Local Improvements paves no boulevards nor pleasure drives, but only streets and alleys, the principles of utility and economy are paramount, and the idea of beauty is considered only so far as it conforms to these principles. Hence the pavement is designed to take care of itself as much as possible without an elaborate maintenance system. Therefore the slope along the gutters and the crown across
the roadway are both steeper than is ordinarily used for park drives and boulevards where a comprehensive system of maintenance exists, and where beauty is one of the chief points considered. The crowns used here approximate rather closely the average crowns obtained by some of the standard crown formulas such as Rosewater's, Zahniser's and Warren's. One of the very common combinations of crowns used by the engineers of this department is that of 6 inches at the summits and 9 inches at the inlets, for an asphalt pavement with a 30 foot roadway. The following table gives the maximum and minimum limits usually observed in crowns for pavements built by the Board of Local Improvements. The width of the roadway in feet, multiplied by the decimal figures in the crown columns gives the limiting crown in feet for that roadway width. The ordinary crowns provided are usually well within these limits.

<table>
<thead>
<tr>
<th>Wearing Surface of Pavement</th>
<th>Crown in Feet Equals Roadway in Feet Multiplied by the Figures Below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macadam</td>
<td>Maximum. 0.035</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.020</td>
</tr>
<tr>
<td>Asphalt</td>
<td>Maximum. 0.025</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.010</td>
</tr>
<tr>
<td>Asphaltic Concrete</td>
<td>Maximum. 0.030</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.015</td>
</tr>
<tr>
<td>Brick</td>
<td>Maximum. 0.025</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.010</td>
</tr>
<tr>
<td>Creosoted Wood Block</td>
<td>Maximum. 0.025</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.010</td>
</tr>
<tr>
<td>Granite Block</td>
<td>Maximum. 0.025</td>
</tr>
<tr>
<td></td>
<td>Minimum. 0.010</td>
</tr>
</tbody>
</table>

The crowns to be used on a given contract for a pavement are shown for both summits and inlets in a note on the profile. The cross section of the surface of the street is described as an
arc of a circle in the ordinances but it is actually staked out as a parabola during construction because of the greater ease and simplicity of method. The actual difference in results is negligible as a parabola varies from a circle so little in the width of a roadway that the difference is practically imperceptible.

(d) Wings and Offsets.

At all alley and street intersections that are included in the contract the wings have been laid out as stated under, 'Line and Grade'. If the line marks have been located on some offset different from that in use for the other lines on this street a special note is made at that place on the profile. A note is usually made at the intersections stating the manner of meeting the existing pavement if any. Also if there is a sewer in the street to be paved, but none in some intersecting street although one will ultimately be needed there, a wing sewer is provided to extend to the limit of the wing of the new pavement. This wing sewer is shown on the profile with the notes and dimensions necessary for its proper construction for future use.

(11) Construction.

(a) Sewer Adjustment and Curbing.

When construction work is commenced on a new pavement the sewer adjustment or the curb construction is done first. The curb is built first more often than the sewer work but it depends on the circumstances. Often both gangs are working simultaneously on different parts of the street.
The sewer adjustment work consists of adjusting manhole and catch basin covers to grade, cleaning out old basins, replacing defective covers, setting grates where required, laying pipe to drain intersecting streets, building wing sewers or necessary extensions to existing sewers, testing out old connections and building new catch basins and manholes if they are required. This sewer adjustment is in the care of a mason foreman for the contractor and a city mason inspector on the street. The foreman and the inspector each have a blue print of the profile for the pavement, with all the details and dimensions shown for their guidance in adjusting and building all sewer appurtenances to fit the new pavement.

The curbing is one of the first parts completed and serves as a basis from which all the other parts of the pavement are located. Two general types of curb are used. They are stone and concrete curbs. The stone curbing is of sandstone except in a few cases where a contract provides for resetting old limestone curbs already on the street when found suitable. The sandstone for new curbing is obtained chiefly from the Berea district in Ohio. Until the last few years a 5 by 30 inch hand dressed sandstone curb supported on stone blocking was in general use, but of late years it has been displaced by a machine dressed sandstone curb 7 by 18 inches in size, supported on concrete chairs or cradles. The 7 by 18 inch curb is now being superceded by a 6 by 18 inch curb of the same type in all new estimates for pavements in which a sandstone curb is provided, with the exception of streets on a heavy fill. In such cases a greater depth is provided according to circumstances. The concrete support consists of a 6 inch layer of
concrete mixed in the ratio of 1, -3 and 6, two feet in length, placed below the curb at each joint. A layer of the same length and thickness extends up one foot at the back of the curb. The two layers are built in monolithic construction. This method of supporting the stones at the joints gives a very stable curb and eliminates much of the trouble encountered with the old method from curb getting out of alignment. The machine dressed stone also presents a much neater appearance than that of the hand dressed curb.

The concrete curbing may be of the vertical type or of the combined curb and gutter type. The vertical concrete curb is 7 inches in thickness at the top and 9 inches thick at the base, with a depth of 24 inches. It rests on a bed of sand or cinders 6 inches thick. It is usually made of crushed granite and granite screenings mixed with portland cement in proportions of 1,-2 and 4. The exposed surface receives a half inch finish coat of mortar made of 2 parts of portland cement mixed with 3 parts of granite screenings. A gravel and torpedo sand concrete is sometimes specified instead of granite concrete, but in such cases the finish coat is the same as where granite is used in the body of the curb.

Where the concrete combined curb and gutter is used it is made of concrete mixed the same as for the vertical concrete curb, and the same materials are used. The finish coat is the same for the curb portion but the finish on the surface of the gutter is made one inch thick instead of one half inch as on the curb.

The concrete for curbs and curb and gutter is mixed by hand. The contractors in Chicago have not yet found an economical system of machine mixing for this type of work. The principal difficulties
of machine mixing on curb work are the relatively small volume of concrete required for the distance covered and the necessity of having a very stiff or firm dry mix for the concrete forming the vertical portion of the curb. It is necessary for the concrete in the vertical part of the curb and gutter to be very firm so that the face strip may be removed as soon as the concrete takes its initial set, and the finish or plaster coat applied. The dimensions of the curb and gutter used now are as follows:

The depth of gutter, 8 inches and a width of 12 inches. The thickness of the curb is 13 inches and the average height of the top of the curb above the gutter is from 6 to 8 inches depending on the depths of the summits and inlets below the top of the curbs. The curb and gutter rests on a bed of cinders or sand 6 inches in thickness. These dimensions have been used extensively only within the last two years, and combined curb and gutter is still being built with other cross sections, according to ordinances passed before this section was adopted exclusively. The old standard section for many years consisted of a 7 inch curb and a 5 by 18 inch gutter. Later this was superseded by the 8 by 13 inch gutter, which in turn was displaced by a gutter 9 inches in width and 10 inches in depth, in the effort to find a more massive and stable cross section. But the gutter 9 inches in width caused trouble in rolling asphalt near the gutters where the curbs were high. The frame of many of the tandem rollers used in rolling asphalt rests down rather low on the roller and projects about 9 inches beyond the end of the roller wheel, so that near the inlets where the curb was high enough to foul the frame it was difficult to roll a narrow strip adjoining the gutters. Many of the newer
rollers now have higher frames and are able to roll close to any curbs. The 8 by 12 inch gutter was considered to be fully as stable as the 10 by 9 inch section and was adopted generally as being the most satisfactory of all sections tried.

In paving alleys it was customary until about five years ago to use either a wood or sandstone curb. Since then a concrete curb 8 inches in width by 12 inches in depth has been used almost invariably. This curb is constructed of the same material and at the same time as the concrete base or foundation of the pavement. It is also constructed in monolithic connection with this concrete base, the lower 6 inches of the curb being equivalent to a lateral extension of the foundation, and the upper 6 inches projecting above it to form the curb proper. The pavement when laid between these curbs as thus formed, comes flush with their tops, which then become a portion of the available width of pavement so far as traffic purposes are concerned.

(b) Grading.

On most of the streets in Chicago the grading required for a pavement consists of cutting. In parts of South Chicago and in other districts, certain streets require filling. In either case the work of preparing the sub-grade is done by the grading gangs of the contractor without inspection by the Board of Local Improvements, except in special cases. An example of a case where inspection is required is that of a street requiring filling where a supply of objectionable material is easily available. In such a case an inspector is placed on the work to see that no such filling is used. Another case is that of a street which is underlaid with a deposit of good gravel or torpedo sand suitable for making
concrete. In this case an inspector is placed in charge to see that the street is not all torn open by the contractor in an effort to obtain this material for his own use under the pretence of grading the street. In general, though, grading does not require an inspector as the subgrade is always checked by the inspector on the concrete foundation before he permits the concrete to be laid. If the soil is such that rolling is required, the facts as to whether it was rolled or not are plainly evident from the marks of the roller on the surface, and if the soil is sandy, requiring flooding instead of rolling, the flooding is done ahead of the concrete gang under supervision of the inspectors for the gang. Trenches for utilities such as water and gas mains are usually replaced under the inspection of their respective departments and are thoroughly flooded.

In grading a street the earth is usually excavated with pick and shovel and hauled away to dumps in wagons. On certain streets where conditions were favorable small steam shovels of the Thew type have been used very successfully. The curve of the surface of the subgrade is determined with the aid of three strips of wood all equal in length which are called,"tees", and which are used by sighting across the roadway from one to another. The third one is placed at any desired intermediate point, usually the half or quarter points, and the corresponding difference in elevation is measured off on the tee and sighted in line. A stake is then set at this grade.

(c) Foundation.

The foundation which may be either of rolled macadam or concrete is placed on the completed subgrade. The stakes for the
finished surface of the concrete are set by means of tees in the same manner as the subgrade was determined. The inspectors check up these stakes and also the subgrade before the concrete is laid. This is one of the very important duties of an inspector. The grade is checked in the following manner: Stakes for the finished concrete surface are set at the center and quarter points across the roadway, at a summit and at an adjacent inlet. These stakes are sighted in by the use of the tees, the full crown being measured off on the intermediate tee at the center and then dropped one fourth of this distance at the quarter points. Stakes are then sighted in from these stakes to several points on line between the summit and inlet, and the distance from the top of the stakes to the subgrade is measured with a rule to insure that the full depth of the concrete course is allowed. If the subgrade is not true it is trimmed by laborers ahead of the concrete laying gang until it presents the true surface. The same method is used if the foundation is to be of macadam.

The concrete is mixed in machine mixers of various types. With some types the mixer is set up at the intersections and the concrete hauled to its place in carts. With other types the mixer travels along the subgrade just ahead of the concrete course. The fresh concrete is conveyed to the grade by a swinging chute that covers the entire width of roadway within its radius. The concrete is spread with shovels or hoes and tamped until the mortar flushes to the surface.

In constructing macadam foundations the material is hauled in wagons, dumped on the subgrade, and spread with rakes and shovels or forks. It is then bonded and rolled until firm and
compact, in the same manner as that used for an ordinary water bound macadam.

(d) Finish Course.

If the finish course is of the asphaltic concrete or asphaltic macadam types it is laid directly on the foundation. The material for asphaltic concrete is hauled to the street in wagons and dumped in piles at such a distance from the portion already laid that all of the mixture must be turned and distributed to the place where it is to be rolled. The specifications for all asphalt pavements state that the last load of the day shall be dumped and spread upon the street at least one hour prior to the official time of sunset. After dumping it is spread and raked while hot and rolled, after which it is swept with a sprinkling of natural hydraulic cement.

The coarse stone aggregate for an asphaltic macadam surface is spread as for an ordinary macadam, and thoroughly rolled without any fine material being added for bonding. The asphaltic cement, amounting to one and a half gallons per square yard, is then applied while hot, either by a spreading tank or by using hand spreader cans. The voids are immediately filled with half inch stone and the surface is rolled again. The excess stone is removed and another application of a half gallon of asphaltic cement per square yard is poured. Then the surface is dressed once more with stone chips and finally rolled again.

The other types of wearing surface are placed upon either a cushion or binder course. For brick or granite this cushion consists of 2 inches of sand. For crested wood block it consists of either 1/2 an inch of 1 to 4 mortar of portland cement and torpedo
sand, or of 1 inch of sand. These sand or mortar beds are trimmed and shaped by skillful bed makers who use a tool which is simply a wooden scraper on a long handle similar to a squeegee in appearance. If the bed consists of mortar it is sprinkled with water just previous to laying the blocks upon it. If the finish course is placed upon a binder course, as in a sheet asphalt, the binder is mixed at the plant and hauled to the street in wagons and dumped, spread, raked, rolled and finished while at a temperature of about 250 degrees Fahrenheit.

The finish course proper or wearing surface is then constructed. If it is of sheet asphalt it is hauled to the street and spread, raked and rolled while hot, and then dressed with a sweeping of natural cement as described for asphaltic concrete. If the finish course is of the block or brick type, the blocks or bricks are distributed and piled along the street previous to being laid. When the paving gang begins work the material is carried from these piles to the advancing edge of the pavement and placed there in small convenient piles by the pavers helpers. The pavers then lay them in courses in the pavement. A portion of the gang follows filling the joints and applying the top dressing.

(e) Inspection.

The construction of all pavements built for the Board of Local Improvements is carried on under the supervision of regular inspectors of the Board. The sewer adjustment work is inspected by mason inspectors who are required to be masons or brick layers by trade. The balance of the field construction is inspected by paving inspectors who understand pavement construction and have demonstrated their ability to perform their duties properly by
passing a civil service examination for their position.

The curb and gutter construction can be inspected by one inspector if the work is not spread out along the street too far. But if the concrete mixing gang is located at an intersection a considerable distance from the forms in which the concrete is being placed, two inspectors are necessary to inspect all the details properly. Where two are used, one gives his attention to the mixing and the other attends to the setting of the strips or forms, the laying of the sand or cinder foundation, and the placing of the concrete. Where sandstone curbs are constructed, only one inspector is required and frequently one inspector supervises the work of two gangs if they are working close together.

The construction of the concrete foundation generally requires two inspectors for its supervision. One checks up the amounts of materials on hand and used, and inspects the mixing. The other is out on the subgrade where the concrete is being laid and checks the stakes and the subgrade, and sees that the concrete is placed and tamped properly. For a macadam foundation only one inspector is usually required and he often supervises the work of two gangs laying, spreading or rolling the slag or stone, if they are not too widely separated.

The inspection of the sheet asphalt and asphaltic types of wearing surfaces while being laid on the street usually requires only one man. The operations necessary to construct these surfaces are performed so nearly at the same time, and within such small areas that one inspector can easily oversee the entire operation. An asphalt inspector is also stationed at the plant to supervise the mixing of the ingredients in the proportions specified in the
contract, and to obtain samples of the materials used. In the case of block or brick wearing surfaces, however, more than one inspector is needed. The usual number for such work is two, although three and even four have been found necessary at times. This depends on the particular conditions such as the size of the gangs and the number and distance apart of the places they are working, the quantity being laid, and the amount of culling required. On such pavements the final inspection and culling of the material is done after the surface has been rolled but before the joints have been filled. Where a construction gang is so well organized that they keep the different operations of making and shaping the bed or cushion course, laying the blocks or bricks, and rolling and filling the joints, constantly progressing in their regular sequence, the work extends over a considerable distance. Thus it is not practicable for two men to inspect them all and to inspect and cull the material in a thorough manner, and additional inspectors are used as needed. The creosoted wood blocks are also inspected at the plants while being manufactured and treated. The timber is inspected in the yards before treating, and samples of the oil to be used are taken and mailed to the laboratory of the Board, and all the details of the treatment are carefully inspected. This inspection is done by one of the engineers of the Board and by the regular paving inspectors who are sent out to the plants where the Blocks are to be treated. These inspectors at the creosoting plants are kept informed as to the results of the analyses of the samples of oil sent in by them to the laboratory, by means of telegrams.

(f) Partial Estimates.

The contracts made by the Board of Local Improvements
provide that partial estimates shall be issued to the contractor from time to time as the progress of the work permits. A condition is made that no estimate shall be issued until 15% of the work is constructed, and that no estimate shall be issued for a net sum of less than $1000. The contracts further provide that of the gross amount of work completed on a contract as shown by a partial estimate, 15% shall be retained by the Board and vouchers shall be issued to the contractor for the balance. These estimates are issued by the division engineer of the division in which the work is being constructed. During the construction season the division engineer goes over his division visiting the various contracts under construction. In this way he visits each contract several times a week and keeps informed as to the progress of the work. In addition the inspectors measure up the progress of the work each day and report it on their daily report cards which are mailed each evening to the chief engineer of streets and are kept on file in the office. Thus at any time it is possible for the engineer in charge to make an estimate of the work done and the money due the contractor for any contract under construction. For convenience in accounting these partial estimates are usually drawn for some multiple of one hundred dollars as the net sum due the contractor. At times when a closer partial is desirable a multiple of fifty dollars is used but the general practice is to use a multiple of one hundred next below the actual net amount due. By this practice many tedious arithmetical computations are avoided. It becomes necessary only to write a partial estimate for a gross amount such that 85% of it will be an even multiple of one hundred. For many years the gross amounts equivalent to an 85% net for amounts
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**Plate 2.**

Board of Local Improvements, Chicago, Ill.
ranging from 100 to 1000 had been worked out and listed, for multiples of 100. Additional amounts corresponding to multiples of 1000 up to 10000 were also listed. Thus by a process of addition the amounts corresponding to other multiples of 100 could be easily obtained. It was observed that these gross amounts invariably terminated in a repeating decimal. After experimenting with many combinations and making extensive computations Julius G. Gabelman, assistant chief engineer of streets, devised the table shown on Plates 2 and 3. This table shows immediately the gross amount or 100% for any multiple of 50 up to 27150, when considered as 85%. The method of using the table consists of finding the net figure in the body of the table, and then obtaining the first digits of the gross amount which are shown at the tops of the corresponding columns. These figures are called, "characteristics", in the table from their resemblance to the characteristics of logarithms. The remaining digits of the gross amount are found by reading the figures on the same horizontal line in the column at the extreme right headed, "Mantissae". This name was also given because of a certain similarity to the mantissae of logarithms. The reverse operation is often used also, in which, by selecting the gross amount next below the gross amount actually completed, the corresponding net amount due is quickly obtained. This table has proved very convenient as a labor saving device in the preparation of the large number of partial estimates that are issued during the construction period.
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<td>16800</td>
<td>17650</td>
<td>18500</td>
<td>19350</td>
<td>20200</td>
<td>21050</td>
<td>21900</td>
<td>22750</td>
<td>23600</td>
<td>24450</td>
<td>25300</td>
<td>26150</td>
<td>27000</td>
<td>764.705882</td>
</tr>
<tr>
<td>14300</td>
<td>15150</td>
<td>16000</td>
<td>16850</td>
<td>17700</td>
<td>18550</td>
<td>19400</td>
<td>20250</td>
<td>21100</td>
<td>21950</td>
<td>22800</td>
<td>23650</td>
<td>24500</td>
<td>25350</td>
<td>26200</td>
<td>27050</td>
<td>823.529411</td>
</tr>
<tr>
<td>14350</td>
<td>15200</td>
<td>16050</td>
<td>16900</td>
<td>17750</td>
<td>18600</td>
<td>19450</td>
<td>20300</td>
<td>21150</td>
<td>22000</td>
<td>22850</td>
<td>23700</td>
<td>24550</td>
<td>25400</td>
<td>26250</td>
<td>27100</td>
<td>882.352941</td>
</tr>
<tr>
<td>14400</td>
<td>15250</td>
<td>16100</td>
<td>16950</td>
<td>17800</td>
<td>18650</td>
<td>19500</td>
<td>20350</td>
<td>21200</td>
<td>22050</td>
<td>22900</td>
<td>23750</td>
<td>24600</td>
<td>25450</td>
<td>26300</td>
<td>27150</td>
<td>941.176470</td>
</tr>
</tbody>
</table>

**Plate 3.**

BOARD OF LOCAL IMPROVEMENTS CHICAGO, ILL.
(12) Measurement and Final Estimates.

(a) Field Work.

After the pavement construction has been completed the entire pavement is measured by the engineers. The measuring party usually consists of two chainmen and a recorder. The notes are kept in the ordinary field note book. A sketch of the improvement is made on one side of the book and the measurements and dimensions are recorded in their relative locations. Additional explanatory notes are entered on the sketch or on the opposite page, and blank space is left for computations.

(b) Office Work.

After an improvement has been measured the quantities are computed and checked in the office. The computations and notes are entered in the field book in the blank space provided with the field notes. The book used is one of a regular series and is completely indexed so that the entire set of notes for a particular contract is compactly located and is easily available for reference. The final estimate is made up from these notes on the same forms as those used for partial estimates. At this time, however, only five per cent is retained as a reserve according to the original contract. The assessment roll is then recast with the final estimate as a basis, plus five per cent to cover shrinkage and cost of collection. It is reviewed by the court again and when approved, it is certified to the collector for collection.
IV. RECORDS AND FORMS.

(1) In the General Office.

(a) General Index Books.

A set of general index books is maintained for general reference. These books are kept in the general office. They are posted up to date and show the history of all proceedings for improvements under the Board of Local Improvements. The books are large ones and the log or record of each improvement occupies one line across the book for the entire width of two adjoining pages. These pages are ruled in columns and the information is shown under the following column headings taken from left to right:

- Nature of improvement.
- Roadway.
- Yardage and frontage.
- Street.
- From.
- To.
- Origin.
- Referred for report, (date).
- Estimate ordered, (date).
- Estimate received, (date).
- Resolution adopted, (date).
- Public hearing, (date).
- Action at public hearing.
- Number and hour of public hearing.
Protest filed, (date).
Ordinance number.
Ordinance sent to council, (date).
Ordinance passed by council, (date).
Petition filed, (date).
Roll filed, (date).
Calendar number.
Docket number.
Warrant number.
Advertised for bids, (date).
Bids opened, (date).
Date of award and name of contractor.
Final order, (date).
Certified for collection, (date).

(b) Card Index and Document Files.

A card index is also maintained in the general office which shows the foregoing information with additional details on the face of the cards. The cards are 9 1/2 by 12 inches in size and show on the reverse side the summaries of the engineers original estimate, the revised estimate, the details of the contract and the final quantities. Reports, documents and official correspondence relating to improvements are filed under the name of the streets in folders placed in large vertical filing cases.

(2) In the Chief Engineer's Office.

(a) Card Indexes, Improvements, Benches, Efficiency, etc.

When a contract for an improvement is awarded a card is
**Plate 4.**

**Plate 5.**

**Plate 6.**
filled out for the chief engineer's index. This card is shown on Plate 4. As may be noted it gives a summary of the contract items, the parties in charge, the total estimated cost and the assessment as actually confirmed by the court.

A card index of bench marks is also kept in this office. This index gives the location, description and elevation of all the city standard benches, and also of the permanent secondary benches or turning points. The cards also show the origin of the bench, the engineer who established it, the date, the book number, and the bench from which the original levels were run. Additional spaces are provided for recording subsequent readings and checks by other engineers. One of these cards is shown on Plate 5. These benches are numbered according to the number of the card. The key to this index consists of a small atlas of the city on which the number of the bench is shown in its proper geographical location. Any one desiring a bench in a certain vicinity simply looks up the cards corresponding in number to those shown near there on the atlas, and obtains the desired information.

An efficiency card index is used to keep a record of the efficiency of the various employees of the paving division. A card is made out for each individual, showing the name, address, department, bureau, position, civil service classification, etc. Lines are ruled on each side of the card. A print of the face of one of these cards is shown on Plate 6.

Another card index which is very useful is the index of roadway widths. A card is headed for each street and on the lines below are shown the various portions of the street which have been paved with their limits, and the corresponding width of roadway.
PLATE 7.
The date and the page number of the ordinance that authorized the improvement are also noted.

(b) Inspector's and Laboratory Reports, Cement Tickets, and Instructions to Inspectors.

Printed forms on ordinary postal cards are furnished to the paving inspectors for daily reports. These cards are addressed to the chief engineer of streets at the city hall and are ready for mailing as soon as they are filled out each evening. One form is used for brick, creosoted block and granite pavements, another for asphalt and asphaltic concrete, and a different one still for macadam and asphaltic macadam. Copies of these cards are shown on Plate 7. The inspector on curb stone, curb and gutter or gutter flag uses a different form of report again, and another one is provided for reports by inspectors on grading or concreting gangs. Copies of these forms are shown on Plate 8.

Cement tickets are printed slips sent out to the paving inspector by the cement tester with each load of cement delivered to a paving contract. They are printed in triplicate. A cement ticket shows that the cement has passed the required tests and gives the serial numbers of the tests, which are checked by the inspector with the numbers stamped on the bags from which samples were taken. These numbers must always check with the numbers on the ticket. The cement tickets are turned in to the office to be checked again with the reports of the cement tester to the chief engineer. A sample of one of these tickets is shown on Plate 9, and one of the cement laboratory report blanks is shown on Plate 10.

The details of the manufacture of creosoted wood blocks and their treatment for Chicago paving contracts, is inspected and
<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street</td>
<td></td>
<td>R.L. T. to R.L. T.</td>
</tr>
<tr>
<td>Contractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concreted Today, from</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laid Today, Sq. Tds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Laid, Sq. Tds.</td>
<td></td>
<td>Balance to be Laid</td>
</tr>
<tr>
<td>Cement Used Today, Bbls.</td>
<td></td>
<td>Total Bbls. used</td>
</tr>
<tr>
<td>Test Openings of</td>
<td></td>
<td>Depth</td>
</tr>
<tr>
<td>Concrete Averages</td>
<td></td>
<td>sq. yds. for each bbl. cement</td>
</tr>
<tr>
<td>Remarks:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Remarks:                                        |       |                          |

**Grading and Concrete: 191 A.M. P.M.**

**Curb and Gutter: 191 A.M. P.M. Sub-Paving Inspector.**

Plate 8.
<table>
<thead>
<tr>
<th>No.</th>
<th>8599 P</th>
</tr>
</thead>
</table>

**BOARD OF LOCAL IMPROVEMENTS.**

Chicago, 191

To

Inspector on

This cement has been accepted by City Cement Tester.

Bag Nos.

Brand


Lab. No.  

---

Plate 9.
<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>PERIOD</th>
<th>CYL. READINGS</th>
<th>TIMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Doors Closed</td>
<td>Ins. &quot;Hr.&quot;</td>
<td>Degs. F.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vacuum 1st</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steaming or Oil Seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vacuum 2nd</td>
<td>(Max.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vacuum 1st Hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vacuum 2nd Hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creo. Introduced</td>
<td>Lbs. Pres.</td>
<td>Degs. F.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pres. (Applied)</td>
<td>(Max.)</td>
<td>(Max.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pres. 1st Hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pres. 2nd Hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pres. Released</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creo. Forced Back</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OIL: Same as Sample No. Sp. Gr. @ °F. Mailed Accepted

Pounds Oil Absorbed per Cu. Ft. (PLACE REMARKS ON BACK OF SHEET)

PLATE II.
reported by the representative of the Board who is at the plant. The reports are sent by mail and are supplemented by telegrams as to shipments, car numbers, etc. as may be necessary. One of the report blanks is shown on Plate 11.

Asphalt laboratory reports are sent in to the chief engineer of streets by the asphalt chemist on report card blanks as shown on Plate 12. Similar reports are made on the results of the analyses of samples of creosote oil mailed in by the inspectors at the creosoting plants. The asphalt inspectors at the plants are on duty during the time the material is being manufactured which is usually from one or two o'clock in the morning to a little after noon. Then they come in to the laboratory and bring in their samples and fill out a report in the record book which is made out on the following form:

<table>
<thead>
<tr>
<th>Date</th>
<th>Plant No.</th>
<th>Street</th>
<th>Asphalt Kind</th>
<th>Flux Kind</th>
<th>Box Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Asphalt Kind</td>
<td>Flux Kind</td>
<td>Top Binder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A.C.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P.C.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O.S.M.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>

P.C. ——— Stone ———        
S.D. ——— Gravel ———        
Sand ——— Sand ———        
Stone ——— O.S.M. ———        
Total ——— Total ———        
### Samples of Asphalt Cement

<table>
<thead>
<tr>
<th>AVE. COMPOSITION</th>
<th>SAMPLES</th>
<th>KIND OF ASPHALT CEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunnen</td>
<td>R. A.</td>
<td></td>
</tr>
<tr>
<td>Passing 200 mesh</td>
<td>R. A.</td>
<td></td>
</tr>
<tr>
<td>100 and 80 mesh</td>
<td>R. A.</td>
<td></td>
</tr>
<tr>
<td>50 and 40 mesh</td>
<td>Flux</td>
<td></td>
</tr>
<tr>
<td>30, 20 and 10 mesh</td>
<td>Flux</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top: No. loads</th>
<th>Boxes</th>
<th>Est. Sq. Yds.</th>
</tr>
</thead>
</table>

---

**Plate 12.**
A sheet of instructions to inspectors has been prepared and distributed to them for their guidance. These instructions are typewritten forms and are as follows:

Instructions to Paving Inspectors.

"General:

All paving inspectors shall report at the particular work to which they have been assigned, at the time work commences in the morning. They shall remain on same until day's work is completed in the evening excepting at the noon hour, unless otherwise ordered by their superiors.

Inspectors shall be in such proximity to the work as to carefully note the character of the work being done.

Inspectors must see that they are provided with a copy of the specifications and of the profile and must familiarize themselves with the conditions thereon. An unauthorized departure from the conditions of the same shall be considered an act of incompetency and neglect of duty.

Inspectors must insist that the foreman be provided with a profile, whether on sub-grade, concreting, curbing or paving and must himself be familiar with same and see that its provisions are carried out.

Any violations of the specifications must be promptly
reported to the general inspector.

It is also the duty of the inspector to see that the work is properly barricaded and danger signals placed and that all crossings are kept clear of obstructions. He shall see that all covers are brought to proper grade, shall note conditions of side-walks, crossings, adjoining pavements, etc., and see that the work is finished in every detail.

Inspectors must know that all cement has been tested before being used.

Though an inspector may be charged with the inspection of a particular part of the work, it is his duty to report to his superior officer and have corrected, if possible, any violations of the contract.

If an inspector is replaced by another, he shall furnish the new inspector all profiles, specifications or special instructions together with all data pertaining to the work, in order that the incoming inspector can give proper quantities of material previously laid and thus keep the daily reports continuous from the start to the completion of the work.

Inspectors are admonished that it is expected of them to be courteous and obliging to all persons making inquiries as to character of work. Profane, contemptuous, insolent and discourteous language must be avoided at all times.

Inspectors must report on the 10th day of the month by separate postal card, the work on which he has been engaged during the month, to be compared with a similar report submitted by the general inspector.

After proper investigation, inspectors must submit to the
chief engineer in writing a complete detailed report of any accident on or about the work.

Inspectors when in doubt will confer with the general inspector or division engineer.

Report location of all manholes, catch basins, and other covers not at proper grade.

Give nearest telephone so you may be reached by the office when on the work."

"Daily Reports:

Report postal cards must be carefully filled out in detail and mailed at the close of the day.

State at the top of the card the street or alley or system of streets as given on the specifications.

If working on a system of streets, state under "Remarks" the name of the particular street of that system on which work is being done, giving location of work.

In giving location of work always give the limits between which work is being done, using house numbers where possible. On street car tracks give side of street on which work is done as well as limits.

Inspectors must promptly report any obstructions to the work such as poles, lamp posts, catch basins, hydrants, manholes and electrical equipment, giving the name of the corporations to which they belong. Make every effort to obtain proper name of corporation.

Under "Remarks" state weather conditions, kind of cement, kind of filler, name of brick or granite block and any other information you may see fit.
Mention should be made of any delay in the work, giving cause of delay, such as weather, lack of materials or any unusual happening about the work.

It is important that these report cards be properly filled out and mailed at the close of the day. Non-compliance with this rule will result in suspension for one day."

Curb and Cutter, Curbstone, Concrete Curb, Cutter Flag, etc.

"Inspectors must see that the concrete is mixed in the following manner:

Mix three times dry and twice wet. When cement and screenings are deposited on the mixing board, the same to be mixed twice by turning on the board, then after the coarse granite is deposited, the whole mass is to be turned again. When water is added the entire mixture must be turned again twice, making a turning of the entire mixture five times.

Where cement side walks extend out to the curb line, inspectors must see that these walks are not undermined in removing the old curbs and that the new curbs are properly back filled after being set."

Cement and Tar Tickets:

Inspectors will be held responsible for all tickets of material used in the work.

When material such as cement or tar leaves the jurisdiction of an inspector and is transferred to another inspector, the inspector must so note in his report of material incorporated in the work. He must also send a note with the material stating the quantity and such marks which characterize its inspection for the guidance of the inspector on the work where material is to be used.
Concrete Foundation:

"Inspectors must see that all gutters, inlets, etc., are kept clean and free from debris during the progress of the work and while concrete is being laid.

See that the top of the concrete is so as to allow of slight overlapping of the asphalt at the gutters and iron covers.

Make test openings in the concrete at least every two hundred feet. In reporting give location by block and house numbers of said openings as well as depth of openings. All test holes must be filled with new concrete.

Asphalt Paving:

Inspectors shall, each day, take a sample from one of the loads of wearing course being used, giving location and street number, also the number of the load from which the sample was taken and the time of day, together with the name of the plant from which the same was taken. Give also the location of the plant.

Give the sample to the general inspector or the division engineer to be turned over to the asphalt chemist.

On your report indicate the material laid, whether binder or wearing surface. Measure the depth of the wearing surface every twenty feet after final rolling, and not after initial rolling, and report the average of the days measurements, giving the number of test measurements made.

If both binder and wearing surface are laid at different parts of the street, fill out separate cards for each."
Directions for Sampling Asphalt Top on the Street:

"Use a wooden instrument about two inches in width and sample the load immediately after it is dumped on the street, taking the sample midway between the top and the bottom of the dump. Place all of the sample on a clean piece of paper and press with another part of the paper and any heavy clean instrument to a thickness of from $\frac{1}{4}$ to $\frac{1}{3}$ an inch. Trim to about $2\frac{1}{4}$ by 4 inches, and with a blunt instrument make a groove about half way through the sample about $\frac{3}{4}$ of an inch from the shortest edge. Place in the envelope provided for the purpose and on the envelope write all the information called for.

Never use a hot instrument in contact with the sample.

Guard against contamination with sand and dirt.

Do not allow paper to adhere to the sample."

Asphaltic Concrete:

"See general instructions for asphalt."

Creosoted Wood Block, Granite and Brick Paving:

"Inspectors shall state on their daily report the car numbers of the cars from which the creosoted blocks laid today had previously been taken.

Special attention shall be paid to breaking joints properly when the blocks are laid.

See that the pitch filling is applied hot and enters the joints between the blocks, leaving as little as possible on the surface of the pavement.

Inspectors must know that paving brick has been tested and accepted before being used."
Tarring and Grouting:

"State under 'Remarks' the location where tarring is done, giving the number of yards tarred today and the total number of yards tarred. Give the number of gallons of tar used today and the total number of gallons of tar used.

In taking samples of tar give the tank number, kind of pavement for which it is to be used, the improvement from and to, and the name of the contractor. Date samples the day they are taken!"

Macadam and Asphaltic Macadam:

"See that the street is graded to theoretical grade and properly rolled.

State on the card which course is being built and give the location of the work.

When a course has been bonded, measure the depth of it at least every two hundred feet. Report the location of openings by block and house numbers, together with the depth of the openings.

Inspector's reports under these instructions will be considered as a certification on their part that the work has been carried out in accordance with the specifications, unless special mention is made to the contrary in the report.

On asphaltic macadam streets, inspectors shall each day, take a sample of the asphaltic cement being used. Give the sample to the general inspector or the division engineer to be turned over to the asphalt chemist.

See that the stone is in a bone dry condition before the asphaltic cement is applied."
Repairs of Openings, and Maintenance:

"Report postal cards must be carefully filled out in detail and mailed at the close of the day.

State at the top of the card the street or alley on which repairs were made.

Inspectors on asphalt repairs shall, each day take a sample of asphalt from one of the wagons, state on which street it was used, and from which plant it was taken.

Make a report on each individual opening.

Locate openings by house number, if possible, or by distance from nearest intersection.

Be careful to check with the foreman the exact size of openings which you report, also get the correct numbers of the the permit and the name of the corporation making the openings.

Before leaving the street, go over the entire contract and report any openings which have not been concreted or repaired, and if none appears, state on your card, street in "good condition" or "no openings on street".

Inspectors must enter on their report cards the total square yards of cuts repaired each day, also the total square yards of maintenance laid each day".

(c) Atlases.

Much of the information used by the engineering force of the Board of Local Improvements is contained in atlases. One set of atlases shows all the sewers, sewer appurtenances and sewer grades in red, and the streets and street grades in black. These details are drawn on a scale of 200 feet to the inch. The drawings
Office of the Board of Local Improvements

No. ........................................................................ CHICAGO, .............................................................. 191

To...........................................................................................................

You are hereby notified that an opening has been made in the pavement
of ...........................................................................................................
(street) (avenue) from ...........................................................................
(street) (avenue)

To ...........................................................................................................

at ...............................................................................................................

and you are further notified to repair and replace said pavement in accordance with your contract and specifications, within
five days from this date, and that in case of your default so to do, your bondsmen will be notified as the law directs.

BOARD OF LOCAL IMPROVEMENTS,

By ................................................................................................. President.

Attest: .............................................................................................. Secretary.

Size of Opening ......................................................................................

Charge to Permit No. .............................................................................

NOTICE—Send bill with this Order to Permit Department Bureau of Streets, when work is completed.

[P. W. F. 153 7-28-13]

PLATE 13.
are in ink on a heavy fibre card board. These atlases are in constant use and have become somewhat worn. A new set is being prepared under the direction of the assistant chief engineer of sewers which is being drawn on tracing cloth. Prints will then be made and bound for the atlases and when they become dilapidated and out of date they can readily be replaced with new prints.

For keeping a convenient graphical record of the streets which have been paved and the materials with which they have been paved as well as the date of paving, a single large atlas is used. The drawings are made to a 400 foot scale and show only the streets and alleys. As portions of streets become paved the information is entered in its relative location on the atlas in conventional colors and symbols to designate the different materials. The year the street was paved is shown by writing it along the street in its relative place on the atlas.

(d) Maintenance during reserve or guarantee.

In connection with the contractor's guarantee to keep the pavement in first class condition during a stipulated number of years, it is also agreed that all openings made in the street during that period shall be repaired by him and paid for at rates agreed upon in the contract. Payment is made from funds deposited with the City by the parties making the openings. These repairs, as well as any repairs required because of some defect or the failure of any portion of the pavement, which are made without compensation, are all supervised by the general inspector in charge of repairs. Measurements are taken and recorded in the record of maintenance and repairs, for all the patches made on each contract. These records are kept in large books a page of which is shown
<table>
<thead>
<tr>
<th>Permit Number</th>
<th>Date of Permit</th>
<th>Date of Corp Notice</th>
<th>Date of City Order</th>
<th>To Whom Issued</th>
<th>Size Opened</th>
<th>Location</th>
<th>Contractor</th>
<th>Safety</th>
<th>Warranty No.</th>
<th>Document No.</th>
<th>Volume No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**PLATE 14.**
<table>
<thead>
<tr>
<th>Street No.</th>
<th>Letting No.</th>
<th>Name of Street</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Contractor**

<table>
<thead>
<tr>
<th>Date Completed</th>
<th>Date Accepted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GUARAN**

<table>
<thead>
<tr>
<th>PERMIT NUMBER</th>
<th>DATE OF PERMIT</th>
<th>DATE OF CORP. NOTICE</th>
<th>DATE OF CITY ORDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
on Plate 13. When a permit to make an opening in a pavement which is under reserve, is issued by the permit office, a notice is mailed to the contractor and a copy is sent to the general inspector in charge of repairs. This form may be seen on Plate 14. During the summer months the different paving contractors usually maintain several gangs to do this repair work. Before the final expiration of the guarantee on a pavement a final inspection is made and if any defects are found a notice is sent to the contractor on a regular blank form. A similar notice is also sent to his surety informing him of the notice sent to the contractor. These repairs are then made under inspection and as the street is then in a satisfactory condition the pavement is finally accepted at the expiration of the guarantee period. Then the balance of the contractor's money which had been held in reserve is paid over to him and the pavement passes from the jurisdiction of the Board of Local Improvements to the bureau of streets of the Department of Public Works.

(3) The Division Engineer's Records.

The division engineer keeps records of the proceedings for improvements in his division, only so far as they affect his duties. Each engineer follows his own ideas in arranging his work, but practically all of them follow the same general system varying only in details.

(a) Order List.

An order list is kept upon which each proceeding is entered as soon as the engineer receives notice that it has been referred
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Roadway New</th>
<th>Roadway Old</th>
<th>Old Paving</th>
<th>Levels</th>
<th>Line &amp; Grade</th>
<th>Ord.</th>
<th>Doc.</th>
<th>Warrant</th>
<th>Specifications</th>
<th>Letting</th>
<th>Contractor</th>
<th>Sub-Cont’r</th>
<th>Commenced</th>
<th>Finished</th>
<th>Final Measure</th>
<th>Plat No.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>ESTIMATE QUANTITIES</th>
<th>FINAL QUANTITIES</th>
<th>Estimate</th>
<th>Contract</th>
<th>Final</th>
<th>PARTIAL ESTIMATES</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curb ( )</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Gutter</td>
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<tr>
<td>Curb Reset</td>
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<tr>
<td>Curb Wall</td>
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<td></td>
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<tr>
<td>Cut, Fill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paving ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Catch-basins</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Old Catch-basins</td>
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<td></td>
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<tr>
<td>Old Manholes</td>
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<tr>
<td>New Covers</td>
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<td></td>
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<tr>
<td>Tile Pipe</td>
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<tr>
<td>Iron Gratings</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Brickwork</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sidewalk</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| Total               |                  |          |          |       |                   |      |
| Amt. Available      |                  |          |          |       |                   |      |

**Plate 15.**
to him for a report. This list shows the name of the streets, the limits between which it is proposed to pave it, and the paving material proposed. Blanks are provided on which to record the preliminary steps in the proceeding which are, the submitting of the report, the return of same with an order for an estimate, the receipt of a plat from the bureau of maps and plats, the field work with the number of the field note book and page number, and finally the date on which the estimate was submitted.

(b) Plat Filing.

Plats when received are recorded on the order list as on hand and are folded and filed in a vertical filing case under an index number. At the same time an index card is made out for the improvement by title only, the space for the estimate details being left blank and only the plat number is recorded. This card is then inserted in its respective place in the card index.

(c) Card Index.

The division engineer's card index consists of the cards previously mentioned. After the levels are run and all necessary surveys are completed, the date and book and page number are entered in their proper space. When the estimate is made the totals of the detailed items of the estimate are recorded thus showing a summary of the estimated quantities, prices and costs. Subsequently when the specifications are prepared and the contract awarded, the contract prices and totals are entered in the contract column. Also at this time blank leaflets are filled out which are identically the same as the index cards except that they are printed on thin paper and are perforated for binding in a loose leaf note book. Copies of the cards are made on these leaflets and the division
engineer and his assistant place them in their note books for convenient reference in the field. Samples of these leaflets may be seen on Plate 15. The general information is entered on the front and the details on the reverse side. When the pavement has been completed and the final estimate is made, the final quantities are entered in the column provided for them. Partial estimates are recorded as they are issued, in the extreme right hand column of the reverse side. When the final quantities are multiplied by the contract prices previously entered, they give the final estimate which is entered in its column. All the other blanks on the front are then filled out and the card is removed from the live index and placed in the index of completed streets for future reference.

(d) Estimate Blanks.

For convenience in preparing estimates of the cost of paving improvements, printed forms are used with blank spaces for the insertion of the specific information. These forms consist of inside sheets and cover sheets. The inside sheets are ruled in columns in which are spaces for showing the legal descriptions of property affected, when necessary, the frontage and the estimated quantities required for the pavement and their distribution, with a final recapitulation or summary of the entire estimate. The first sheet is provided with blanks for the title of the improvement, the limits and the exceptions. The material to be used is then stated, followed by a summary of the estimated quantities and costs. This is followed by the plan of assessment, the present and proposed roadways, any necessary remarks and the date and signature of the engineer. These estimates are used as the basis upon which the assessment roll is cast and the paving ordinance is drawn.
V. TYPES OF PAVEMENT CONSTRUCTED.

(1) General Features.

(a) Subgrade.

The material usually found in the subgrades of Chicago pavements is of two kinds, sand and clay. On streets which are located within a few miles of the lake sand is usually found and is very readily compacted by flooding with a fire hose. On streets located back several miles from the lake clay is ordinarily encountered and is rolled with a ten ton roller until thoroughly consolidated.

(b) Drainage.

The general features of the drainage of Chicago pavements are explained on pages 11 and 12, and on pages 27 to 32. The new catch basins found necessary are located in the most advantageous position with reference to the old ones already in the street, as was stated under, "Location of Catch Basins". These basins are circular in section, with an internal diameter of 4 feet. They are drawn in to an internal diameter of 2 feet at the top. The basins are built of 2 rings of brick and mortar on a floor of 2 inch planks. Their depth is 7 feet, 2 inches without the cover. The basins are connected to the sewer by a 9 inch half trap set 3 1/2 feet above the floor of the basin.

The covers of all catch basins and manholes are made of cast iron. The curb weighs 410 pounds and the lid weighs 160 pounds. In parkways a lawn cover is used which weighs 315 pounds complete. Lip covers were formerly used for catch basins located in the...
gutters, but for the last year man hole covers with heavy perforated lids have been used for such basins.

Where the basins do not come in the line of the gutter standard 17 by 24 inch grates are used. They are placed in the gutter on a brick foundation and connected to the basin by a 9 inch pipe.

(c) Foundation.

The foundations used for pavements are of either concrete or macadam as was stated in the discussion of the engineer's report. When concrete is used it is made of portland cement mixed with sand or screenings, and stone, slag or gravel, taken in the proportions of 1, 3, and 6, respectively. It is mixed in approved batch machine mixers or on movable tight iron platforms. The hand method of mixing, though, has been almost entirely discarded in this city for pavement foundations. The concrete is usually mixed rather wet and tamped until the mortar flushes to the surface.

When macadam is used it is composed of stone or slag and is usually rolled in one course. But occasionally provisions are made for rolling and bonding a 5 inch course and then repeating with a 3 inch course, before placing the wearing surface. These macadam foundations are constructed in practically the same manner as that for an ordinary water bound macadam pavement.

(d) Curbing.

Sandstone and concrete are the two materials used for curbing in Chicago by the Board of Local Improvements. The various types and dimensions are described in the discussion of curbing under "Construction", on pages 35 to 38. The sandstone curb is used principally with granite block, brick or macadam pavements.
Its use is decreasing, however, and its place is being taken to a considerable extent by the concrete vertical curb. The combined curb and gutter is used with asphalt and asphaltic concrete pavements, and occasionally with brick and creosoted wood block surfaces. The vertical concrete type is commonly used with the two latter surfaces, combined curb and gutter being built only in cases of old proceedings that have been in litigation or have been otherwise delayed several years. The new proceedings provide for vertical curbs for pavements with these surfaces. The combined curb and gutter type is not used now where a rolled foundation is provided. This is because the roller often forces the soil back under the gutter and tilts it out of position, causing breaks in the curbing at various places.

(2) Asphalt Pavements.

(a) Standard Sheet Asphalt.

The common or standard type of sheet asphalt pavement built in Chicago consists of 2 inches of sheet asphalt on 1 1/2 inches of binder, on a 6 inch concrete foundation. It is sometimes laid on an old macadam foundation, though, in place of concrete.

The binder is prepared by heating stone or gravel of sizes ranging from 1 inch downward, with sand, to a temperature of from 200 to 325 degrees Fahrenheit. They are then mixed with asphaltic cement in such proportions that the weight of the material passing a 10 mesh screen is between 25% and 35% of the total weight, and the bitumen is between 5% and 8% of the entire mixture.
by weight. The use of old asphaltic surface paving mixtures in combination with binder stone is permitted when it is augmented with fresh asphaltic cement, and provided the mixture complies with the foregoing requirements.

The wearing surface consists of asphaltic cement mixed with carbonate of lime or portland cement, and sand, so proportioned that the average weights of the various ingredients are as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen soluble in cold carbon disulphide</td>
<td>11.0 to 13.5%</td>
</tr>
<tr>
<td>Portland cement or carbonate of lime passing a 200 mesh sieve</td>
<td>10.0 to 15.0%</td>
</tr>
<tr>
<td>Sand passing an 80 mesh sieve</td>
<td>18.0 to 36.0%</td>
</tr>
<tr>
<td>Sand passing a 40 mesh sieve</td>
<td>20.0 to 50.0%</td>
</tr>
<tr>
<td>Sand passing a 10 mesh sieve</td>
<td>8.0 to 25.0%</td>
</tr>
<tr>
<td>Sand passing a 4 mesh sieve</td>
<td>0.0 to 10.0%</td>
</tr>
</tbody>
</table>

The sieves are used in the order named above. The sand and the asphaltic cement are heated separately to about 300 degrees F., and not exceeding 375 degrees F., for the sand at the mixer; and not exceeding 335 degrees F. for the asphaltic cement at the discharge pipe. The hot sand is mixed with the portland cement or the carbonate of lime and then this mass is mixed with asphaltic cement for at least one minute and until a homogenous mixture is produced. This hot mixture is hauled to the street in wagons and placed on the street as stated under "Construction".

The asphaltic cement used is prepared from a refined asphalt, or a mixture of equal parts of different refined asphalts, combined with a flux if necessary. The entire amount of the refined asphalt used is not permitted to be less than 50% of the whole mixture by weight. If the weight of the flux exceeds 25% of the
asphaltic cement an asphaltic or semiasphaltic flux is required. The flux is melted together with the refined asphalt in kettles at temperatures between 250 and 375 degrees F. When hot, it is thoroughly agitated until it has become completely mixed forming a homogenous mass of asphaltic cement. Any portion settling in the kettles during the intervals when it is not being used is thoroughly agitated again before being drawn for use. A penetration of from 30 to 85 degrees is required, which is varied between these limits to fit the particular kind of asphalt used, or to meet local traffic conditions. The asphaltic cement must also meet the following requirements:

Samples of the paving mixture are taken at the plant and from the street. When 50 grams of the mixture are heated for 5 hours at a temperature of 325 degrees F. in a tin box 1 inch in depth by 2 1/4 inches in diameter, not more than 5% of the bitumen shall be volatized nor may the penetration at 77 degrees F. after such heating be less than one half of the original penetration. Briquettes of the bitumen from the asphaltic cement must have a minimum ductility of 10 centimeters.

The flux used in preparing the asphaltic cement may be either a paraffine, an asphaltic or a semi-asphaltic residuum. It must be tested with the asphalt to be used and found to be suitable to it. A minimum penetration of 350 degrees is required. The penetration is measured in hundredths of a centimeter with a number 2 needle applied at 77 degrees F. for one second under a weight of 50 grams. At least 99% of all residuums must be soluble in cold carbon tetra chloride. The requirements as to other properties vary depending upon the kind of residuum being used. For a paraffine
residuum a specific gravity at 77 degrees F., of from 0.92 to 0.94 is required. When tested in a New York State Closed Oil Tester it must not flash below 350 degrees, and when heated in a tin box as described for asphaltic cement not over 5% may be volatilized. When an asphaltic residuum is used its specific gravity at 77 degrees F. may not be over 1.04 nor less than 0.93. This residuum is required to have a ductility of not less than 30 centimeters after evaporation at 500 degrees F. to a solid of from 50 to 60 degrees penetration. Its other requirements are the same as for paraffine residuums. If a semi-asphaltic residuum is used its general requirements are the same as for a paraffine residuum except that its specific gravity is required to be between 0.94 and 0.98, and that its viscosity coefficient, as determined by the Engler viscosimeter, must be less than 16 at 212 degrees F.

The refined asphalt which is melted together with the flux to form the asphaltic cement is derived in one of three ways described briefly as follows:

1. Crude native solid asphalt which may be any native mineral bitumen, either pure or mixed with foreign matter, and which has a penetration greater than 100 degrees, is heated if it requires refining, to a temperature of not over 450 degrees F. until all water and light oils have been driven off. Of the bitumen contained in the refined asphalt which is soluble in cold carbon disulphide, at least 98.5% must be soluble in cold carbon tetra chlorid.

2. Asphaltic petroleum is carefully distilled with steam agitation at a temperature not greater than 700 degrees F., until a residue having a penetration no greater than 30 degrees is obtained. This residue must be soluble in carbon tetra chloride to
to the extent of 98 1/3\% \text{, and its bitumen must not yield over 15\% of fixed carbon upon ignition. Not exceeding 5\% may be volatilized when 30 grams are heated to 325 degrees F. in a tin box as previously described, and its penetration after heating may not be less than one half the original penetration. It must have a minimum ductility of 30 centimeters when brought to a penetration of 50 degrees, either by heating at a temperature below 500 degrees F. or by the use of a combining flux. All shipments of this material are marked with a lot number, and the penetration. Ten samples are taken at random from each lot and tested and a maximum variation of 15\% from the average penetration is allowed.}

3. Crude native solid asphalt is combined with asphaltic or semi-asphaltic flux which fulfills the requirements previously stated. The proportion of the flux to the bitumen contained in the crude asphalt is not permitted to exceed 40\% by weight and the penetration of the resulting refined asphalt is not permitted to exceed 40 degrees.

When different refined asphalts are combined to produce asphaltic cements, only asphaltic or semi-asphaltic fluxes are permitted, with the exception that where the crude asphalt is of such character that the mixture with paraffine flux without adding any other material, will produce an asphaltic cement fulfilling the requirements previously stated; any of the fluxes mentioned before are permitted. All the details of the preparation and refining of asphalts used in paving are under the inspection of inspectors from the asphalt laboratory of Board who are assigned to the asphalt plants and report to the laboratory as shown in a preceding section. The standard sheet asphalt pavement has been
built more extensively in Chicago than any other type of pavement during recent years. It has been used satisfactorily for so many years that its reputation as an excellent material for street pavements is firmly established.

(b) Type B Asphalt.

The pavement built by the Board of Local Improvements and designated by them as type "B" asphalt, differs from the standard sheet asphalt pavement only in the thickness of the various courses. The foundation is either 5 inches or 6 inches of concrete. The binder course is only 1 inch thick instead of 1 1/2 inches as in the ordinary sheet asphalt and the wearing surface instead of being 2 inches is only 1 1/2 inches thick. This type of pavement is used on light traffic streets where it is thought that conditions do not require such a thick pavement as the regular sheet asphalt. It has been in use only during the last year or two and therefore no data as to its durability are available. So far, however, no very marked reduction in prices from those of the regular type, have been obtained for this lighter type.

(c) Asphalitic Concrete.

The asphalitic concrete pavement consists of 2 inches of asphalitic concrete wearing surface on a 5 or 6 inch concrete foundation or on a macadam foundation, which may be 6 inches of new slag or stone or it may be an old macadam pavement redressed or reshaped to receive the wearing surface.

This wearing surface consists of asphalitic cement and mineral aggregate. The asphalitic cement is prepared from refined asphalt and flux where necessary. The requirements for each of these materials are identical with those for the asphalitic cement
used in the sheet asphalt pavements.

The mineral aggregate consists of granite, sand and pulverized carbonate of lime. The granite is crushed and of such sizes as will pass through a half inch ring and be held on a one tenth inch ring. The sand is graded as shown in the following paragraph, not over 6% of particles passing a 200 mesh sieve being allowed. The proportions of the different materials and sizes used in the wearing surface are as follows:

- Bitumen soluble in cold carbon disulphide 7.0 to 11.0%.
- Carbonate of lime passing a 200 mesh sieve 5.0 to 11.0%.
- Sand passing a 40 mesh sieve 18.0 to 30.0%.
- Sand passing a 10 mesh sieve 25.0 to 55.0%.
- Broken granite passing a 4 mesh sieve 8.0 to 22.0%.
- Broken granite passing a 2 mesh sieve less than 10.0%.

The entire quantity of the granite aggregate, however, is required to be not less than 25% of the whole mixture.

The mixed sand and granite and the asphaltic cement are heated separately to a temperature of from 300 degrees F. to 375 degrees F. The carbonate of lime is mixed while cold with the hot sand and granite. The asphaltic cement is then added and mixed as described for sheet asphalt. The mixture is hauled in wagons and laid on the street while hot in the same manner as that explained under sheet asphalt.

The asphaltic concrete type of pavement has been built in Chicago by the Board of Local Improvements only about two years and consequently no comprehensive information is available as to its wearing qualities. Those built seem to be giving good satisfaction for the short time they have been in use and the
demand for this type of pavement is increasing. The South Park Board laid several asphaltic concrete pavements on its boulevards for two or three years previous to the adoption of this type by the Board of Local Improvements and they have given good service for boulevard traffic. The South Park type differs somewhat from that of the Board of Local Improvements both in the asphalt or bitumen and in the mineral aggregate.

(3) Brick Pavements.

(a) Foundation.

For brick pavements a six inch concrete foundation is regularly used, on which is placed a two inch bed of sand to form a cushion for the brick wearing surface.

(b) Bricks.

The bricks used are vitrified paving bricks which are required to be thoroughly annealed, tough, durable and evenly burned. All bricks were formerly required to be repressed but this has not been required on some of the more recent contracts. Kiln marks and surface cracks not exceeding 3/16 of an inch in depth are permitted. The dimensions are the same for the bricks used throughout any one contract, and are not less than 8 inches in length, 4 inches in depth and 3 1/4 inches in thickness. The edges are rounded to a radius of 1/4 of an inch.

(c) Tests.

The bricks, when broken, are required to show a dense and stone like body, with a uniform inside color. Lumps of uncrushed clay or lime, air pockets, cracks, or marked laminations are not
permitted. The principal test required is that for abrasion. This test was made for several years in what is known as the Chicago rattler, which was 28 inches in diameter and 20 inches long, inside measurements. This machine is still used for testing bricks where the paving ordinance requires it, but it is being superseded by the test and rattler designed for the National Paving Brick Manufacturer's Association. Both rattlers are so well known that they will not be described here. In each case the maximum allowable loss of weight by abrasion after the rattler has revolved through 1800 revolutions is 20 per cent.

(d) Laying and Filling.

The bricks are conveyed to the paver in clamps or pallets, or on roller conveyors. Wheeling the brick in barrows and dumping them is forbidden. The courses are laid at right angles to the curbs except at intersections where they are laid at 45 degree angles. A lap of at least 3 inches is specified for breaking joints.

After the bricks in the pavement have been rolled and culled, the joints are filled with either pitch, asphaltic, or cement grout filler. The pitch filler is most commonly used, chiefly because of its greater convenience and economy. Asphaltic filler is also used extensively and ranks next to pitch from the standpoint of the amount used. It is more expensive than pitch and requires more care in its application. Cement grout filler is not used very extensively for brick pavements built by the Board of Local Improvements. It has long been recognized as an excellent filler, but it is essential that the traffic be excluded from the pavement for several days after the grout has been applied. For this reason it is
not used to any great extent in Chicago.

Chicago is very advantageously located with reference to securing excellent brick for pavements. Consequently many miles of brick pavements have been laid in this city. Some of them have been down for many years and have thoroughly demonstrated the utility, durability and excellence of brick for street pavements.

(4) Granite Block Pavements.

(a) Material.

Granite blocks are used for pavements in Chicago where a dense traffic of a heavy character exists, and where noiselessness is not a paramount requirement. The foundation, consisting of 6 or 8 inches of concrete, is covered with a bed of 2 inches of sand on which the blocks are placed. This bed, however, is not shaped with a template or smoothing tool as for brick, but the paver tamps the sand under each separate block as he places it in position. The material from which the blocks are cut is granite, "having a uniform grain and texture without lamination or stratification and free from an excess of mica or feldspar". The size of the blocks varies from 3 1/4 to 4 1/4 inches in width, 6 to 10 inches in length and 3 3/4 to 4 1/4 inches in depth. A block 5 inches in depth has been used in the past, but the tendency has been to provide for 4 inch blocks in recent years. The blocks are dressed so as to present, "substantially rectangular" surfaces. In defining, "substantially rectangular", the following maximum variations from a straight edge applied to the various surfaces is permitted:

On the wearing surface, 3/8 of an inch. On the sides or
ends of the block, 1/2 an inch. The surface joints are permitted to have a maximum and minimum width of 5/8 and 1/8 of an inch respectively.

The courses are laid at right angles to the curbs except at intersections where they are laid at 45 degree angles. A minimum lap of 3 inches is required to break joints.

(b) Curb.

Sandstone curbing is most commonly used with granite block pavements. The machine dressed sandstone has practically displaced the old hand dressed type for granite pavements. See the discussion of this curb on pages 35 and 66.

(c) Filler.

The joints in the granite block pavements are first filled with hot dry roofing gravel which is thrown upon the surface and swept into the joints. The blocks are then rammed with an ordinary 75 pound rammer, after which the joints are completely filled with a coal tar paving pitch, which is applied at a temperature between 250 and 325 degrees F. This pitch contains between 20 and 30% of free carbon and melts between 120 and 130 degrees F. Immediately after applying the pitch and while it is still hot the surface is dressed with a 1/4 inch course of hot roofing gravel.

Granite block pavements, because of their relatively high cost, are built here only on streets on which the density and character of the traffic is such that it is thought they will justify the higher cost of the improvement. Therefore the amount of granite pavement laid in this city is relatively small compared to the total amount of pavement laid.

The use of small granite cubes, such as the Durax or the
German Kleinpfaster, has not been given a practical trial in Chicago although this type of pavement is now being given a good deal of general attention.

(5) Creosoted Wood Block Pavements.

(a) Curb.

The vertical concrete curb is the usual type used for curbing on creosoted wood block pavements in Chicago. The sandstone curb has been used occasionally. The combined curb and gutter type was used to a certain extent in former years but its use has been discontinued because the joint between the blocks and the concrete gutter was found to present a line of weakness in the pavement.

(b) Foundation and Cushion.

Creosoted wood block pavements generally have a foundation of 6 inches of concrete, but in the "loop" district an 8 inch concrete foundation is common. On the foundation is placed a 1 inch sand cushion or a 1 1/2 inch mortar cushion, which is shaped as the cushion for a brick pavement. If mortar is used it is sprinkled before laying the blocks as described under construction. The mortar cushion is always provided near the brow along a street car line to prevent the churning of the sand cushion up through the joints of the pavement. This churning is caused by the pounding of the heavy cars over the rails.

(c) Blocks and Timber.

The blocks forming the wearing surface of the creosoted wood block pavements are cut from southern long leaf yellow pine, or tamarack. Black gum was formerly accepted but has not been used
during the last year. The blocks are not less than 5 inches
nor more than 10 inches long, and 3 3/4 inches wide. The depth may
be 3, 5 1/2, or 4 inches depending upon the specifications, as pave-
ments are laid with blocks of either depth. The timber is required
to be of that grade known as "prime" timber. It must be, "sound,
square edged, free from bark, shakes, large or loose or rotten
knots, red heart, worm or knot holes", or other serious defects.
Second growth timber or loblolly pine is not accepted. For long
leaf yellow pine the annual rings must average not less than 8 to
the inch in the first 3 inches measured radially from the heart.
The timber is seasoned to the satisfaction of the Board, and if not
satisfactory it must be piled in such a manner and for such a time
as is necessary to prepare it for the treatment for paving blocks.

(d) Treatment.

The blocks are placed in an air tight cylinder, and the
sap and moisture in them is removed by the application of steam
and the use of the vacuum pump. When the blocks are thoroughly dry
the oil is forced into the cylinder and maintained at a temperature
of not less than 165 degrees F. Pressure is applied gradually, a
maximum pressure of 200 pounds per square inch being allowed. The
pressure is maintained until the required amount of oil has been
forced into the fibres of the wood, a minimum pressure period of
3 hours being required. The usual amount of oil required is 16
pounds per cubic foot of wood for the average street. For down town
streets with very dense traffic only 12 pounds is required, as it
is considered that the determining factor in the life of such a
pavement is the mechanical wear it will receive. On outlying streets
with light traffic the treatment is sometimes as high as 20 pounds
per cubic foot, it being considered that in such a street the natural decay of the wood will be the determining factor in the life of the pavement. If more oil has been injected into the wood than the specifications require it remains there as the manufacturer is not permitted to remove the excess.

The oil used in treating the wood is a pure coal tar distillate. Oil containing any other material not obtained by distilling coal tar, or oil containing more than 1% of matter insoluble in hot benzol and chloroform, is not accepted. The specific gravity of the oil may vary from 1.08 to 1.12. It was customary about 5 years ago to use oil with a specific gravity of from 1.04 to 1.06. Then for a time it was thought that the heavier oils would give better satisfaction, so the specific gravity was increased to from 1.10 to 1.13. It is now considered that the oils with specific gravities ranging from 1.08 to 1.12 give the best results. The present practice, therefore, conforms to these limits.

The oil is distilled to determine the fractions according to the standard fractionation or distillation test recommended by the Society for Standardization of Paving Specifications. The various temperatures with their corresponding maximum allowable distillates are as follows:

- Up to 150 degrees Centigrade: 2 per cent.
- Up to 210 degrees Centigrade: 10 per cent.
- Up to 235 degrees Centigrade: 20 per cent.
- Up to 315 degrees Centigrade: 40 per cent.

The distillation is continued until a temperature of 355 degrees Centigrade is reached. The residue from this distillation is of a soft waxy consistency after it is cooled to 15 degrees Centigrade.
When a small portion of this residue is placed on a piece of white filter paper and heated until it melts, the oil spot left upon the paper is a clear amber in color. The manufacturer of the blocks is required to certify in writing to the Board of Local Improvements, that the oil used is a distillate oil obtained wholly and entirely by distillation from coal tar, and that it is free from any adulteration.

(e) Laying.

The blocks are laid in the pavement in courses at right angles to the curbs except at intersections where they are laid at 45 degree angles. Various angles have been used in former years such as 45 degrees and 68 degrees from the center line. It was found, however, that a 90 degree angle gave as good service as the others and eliminated the difficulty of making mitre joints in the blocks at the ends of the courses. The minimum lap for breaking joints between blocks is 2 inches.

(f) Expansion Joints and Filler.

Expansion joints are provided along the gutters approximately 1 1/2 inches in width. No transverse expansion joints are provided. It was formerly customary to provide 1/4 inch transverse joints every 25 feet, or 1/2 inch joints every 50 feet, or 1 inch joints every 100 feet. On the theory that these joints presented lines of weakness across the pavement they were omitted and expansion joints provided at the sides only. The results obtained were very satisfactory and no more trouble was encountered from expansion than if the transverse joints had been provided. Consequently they have been generally eliminated.

Various fillers have been used for sealing the joints of
oreosoted wood block pavements. Pitch is used very extensively for this purpose. It is of the same character and is applied in the same way as that used for brick pavements. In applying it care is taken to use only enough to fill the joints properly and hold the sand for top dressing, as an excess on the surface is objectionable. Asphal tic filler is also included in the specifications for oreosoted wood block pavements. Both asphalt and pitch, however, if an excess is applied, tend to aggravate the annoyance caused by the exuding of the creosote oil from the paving blocks. In an endeavor to eliminate the annoyance caused by this, "bleeding", of the blocks, sand and cement grout fillers have been used. The sand is applied hot and is swept into the joints until they are completely filled. Cement grout, when used for a filler, is mixed in boxes, then poured upon the surface of the pavement and swept into the joints. It requires several days, though, to set sufficiently to permit traffic upon the street, and any movement of the blocks due to expansion shatters the bond of the cement so that the joints are not sealed. Neither sand nor cement grout seems to make any perceptible reduction in the bleeding of the blocks, and when they do bleed the annoyance is not appreciably less than on pavements with a pitch filler where it has been properly applied. Therefore they are not being used very extensively at present as the pitch filler seals the joints completely and seems to give as good results otherwise as sand or grout.

After the filler is applied the surface of the pavement is dressed with 1/4 of an inch of screened, dry, torpedo sand.

This type of pavement has been in service in Chicago for about 10 years and appears to be making a very good record for
itself, when properly constructed. The downtown business district is rapidly becoming paved with this type of pavement on almost all of its streets. This pavement is well adapted to streets in such a district.

(6) Macadam Pavements.

(a) Water Bound Macadam.

The water-bound macadam pavement which has been so popular in former years is not considered a suitable pavement for city streets under present conditions, and no more proceedings for such pavements are being ordered by the Board of Local Improvements. Consequently their construction has almost entirely ceased in the last few years. The only pavements of this type that have been constructed within the last two years have been those for which the proceedings had been started some years ago and which, because of some litigation or some other delay, had reached the construction stage after the Board had decided to order no more proceedings for this type of pavement. The water bound macadam has been replaced by the asphaltic concrete and asphaltic macadam types of pavements.

(b) Asphaltic Macadam.

While asphaltic macadam pavements have been built in other places, and have been built on some of the park drives in Chicago by the Park Boards for several years, the Board of Local Improvements has been building them by special assessment only about two years. Several small stretches of this pavement had been built by private contract under supervision of the Board
before the year 1912; but the Board desired to ascertain more fully its good features before instituting special assessment proceedings for this kind of a pavement.

The asphaltic macadam pavement is generally constructed on a macadam foundation consisting of 8 inches of slag or stone varying from 2 to 4 inches in size. A 6 inch concrete foundation has been used for the asphaltic macadam wearing surface but the results were not as satisfactory as where a macadam foundation was used and the cost was greater. So the use of concrete foundations for this type of pavement has ceased. The stone or slag used in the foundation is rolled and bonded with screenings, cinders, foundry sand or bonding gravel.

The asphaltic macadam wearing surface is placed upon this foundation. It consists of 2 1/2 inches of crushed limestone, gravel or crushed granite of such size that it will pass through a 2 inch ring. This material is bonded with asphaltic cement and either gravel, limestone or granite chips. The stone must be in a bone dry condition when the asphaltic cement is applied. For the first application 1 1/2 gallons of the asphalt is applied per square yard of pavement. While this application is still hot the surface is covered with the fine gravel or stone chips to fill the voids. It is then rolled and any excess chips are removed.

A second coat of 1/2 a gallon of asphaltic cement per square yard is then applied, and the surface is again dressed with chips and thoroughly rolled. The temperatures at which the asphaltic cement is applied vary to suit the material used.

The asphaltic cement used may be one of the following
types depending upon the specifications for a particular contract:

The first one is prepared from refined natural solid asphalt and a suitable flux. The refined asphalt is prepared to comply with the same requirements as those for sheet asphalt, except that where a flux is used it is specified only, that the flux shall be suitable to the material used. A minimum specific gravity of unity at 77 degrees F. is required, with a minimum of 98 1/2% of the bitumen soluble in carbon tetra chloride. The fixed carbon varies between 8 and 15%, and the melting point varies between 100 and 135 degrees F. The penetration is varied between 80 and 150 degrees to suit the materials used and the conditions on the street. This asphaltic cement is also expected to meet practically the same volatilization and ductility requirements as those for the asphaltic cement for sheet asphalt pavements.

The other variety of asphaltic cement used is required to be free from coal tar or its products but its minimum specific gravity at 77 degrees F. is only 0.965. The bitumen soluble in carbon tetra chloride and the fixed carbon are the same as noted for the preceding cement. It is not accepted if it flashes below 350 degrees F. The minimum and maximum allowable penetration is 80 and 200 degrees respectively. The volatilization test is the same as for the preceding cement, but the ductility test is not required.

The contractor is required to show that the asphaltic cement which he proposes to use, has been used and given satisfactory service in pavements of this character for at least two years.

Asphaltic macadam pavements have been built in Chicago
for about 5 years, and by special assessment for 2 years. When well built they seem to answer the requirements very well. It is doubtful, however, if the use of a soft material like limestone, for the wearing surface is justifiable from a standpoint of durability.

(7) Concrete Pavements.

Concrete pavements are now built in Chicago by the Board of Local Improvements under the special assessment law. The past year was the first one in which such pavements were laid by special assessments. But for several years the Board has approved private contracts for concrete pavements, and has supervised their construction. In addition, there have been several patented concrete pavements laid in Chicago which were not under the supervision of the Board and which are not considered in this discussion.

Three types of concrete pavement have been approved by the Board of Local Improvements and constructed under its supervision. They are: the two course, the one course, and the one course concrete with a bituminous surface. In nearly all cases where such pavements have been laid they have been built in alleys. They have been used for paving streets in rare cases only, and for comparatively small areas.

(a) Two Course Concrete.

The two course concrete pavement consists of one 6 inch course of concrete on which is placed a 2 inch course for a wearing surface. A foundation course only 5 inches thick is now being specified, but practically all the two course concrete pavements
previously constructed have had a 6 inch foundation course. The first course is mixed with 1 part portland cement, 3 parts sand or screenings and 5 parts of gravel. The concrete is placed as for an ordinary pavement foundation and the second course is applied before the first has had time to set. This course consists of concrete mixed in the ratio of 2 parts of portland cement, 1 1/2 parts of torpedo sand and 1 1/2 parts of broken granite such as will pass through a 3/8 inch ring. A maximum period of 45 minutes is allowed between the time of mixing the concrete for the first course and that of covering it with the wearing surface. After the wearing surface has been finished to grade with a straight edge or template it is floated with a wood float or marked in rectangles.

This type of pavement has given satisfactory results in many alleys in Chicago. It is, however, somewhat expensive and is being displaced by the more recent type called the one course concrete pavement.

(b) One Course Concrete.

The one course concrete pavement consists of a single layer of 7 inches of concrete laid on the subgrade. The concrete is mixed in the proportions of 1 part portland cement, 2 parts of torpedo sand and 4 parts of washed gravel. This mix has been used for the one course concrete pavements laid by the Board of Local Improvements previous to this time. The requirements for the coming year have been broadened to permit the use of either torpedo sand or limestone screenings; and either gravel, crushed limestone or slag in mixing the concrete. The proportions have also been changed to 1, 2 and 3 instead of 1, 2 and 4. The optional use of the different materials named allows for full competition and will
probably result in more economical construction, thus compensating for the increased cost of the richer mixture. The concrete is not reinforced as a general rule. Provision is made in the specifications for reinforcing only those pavements over 20 feet in width. A mesh steel reinforcement equal to number 20, American Steel and Wire Company's standard, of not less than 28 pounds per 100 square feet is required. In this case the concrete is laid in 2 courses of 4 and 3 inches, respectively, the reinforcing material being placed between the courses. Since the concrete pavements have been built almost entirely in alleys it is very rarely necessary to use reinforcement, as the roadways are seldom over 18 feet in width.

This form of pavement has been built for two years now and appears to give satisfaction. Several cracks have developed, but no serious defects have been found. Since they have been in service such a short period of time no statement could be made as to their maintenance requirements or durability.

(c) Concrete with a Bituminous Surface.

The concrete pavement with a bituminous surface is an outgrowth of the Dolarway pavement which was developed in Ann Arbor, Michigan, 5 or 6 years ago. This pavement, as laid by the Board of Local Improvements, is identically the same as that previously described for a one course concrete pavement with the addition of a bituminated surface coat. This coat consists of not less than 1/2 a gallon of hot bitumens per square yard of pavement applied to the surface of the concrete. While still hot a thin layer of granite screenings or torpedo sand is spread over it.

These pavements have been built in Chicago for about 3 years. The chief advantage of the bituminous surface is that it
deadens the noise of traffic on the pavement. This coat wears or scales off in many cases within one or two years. If it is desired to keep such a surface on these pavements permanently, it will probably be necessary to resurface them every year or two. If the wearing coat is not renewed when the concrete is worn bare the pavement still gives good service, as it then practically becomes a one course concrete pavement.

Expansion joints are placed in all of the foregoing concrete pavements about 35 feet apart. Two methods of protecting the edges of the joints from abrasion are used. For this purpose either steel plates are anchored in the concrete on each side of the joint, or the pavement, for a distance of 6 inches on each side of the joint, is formed of a rich granite concrete. When the plates are used they are of soft steel 3/16 of an inch in thickness, and 2 1/2 inches in depth. If concrete is used it is composed of 2 parts of portland cement, 1 1/2 parts of torpedo sand and 1 1/2 parts of granite chips. The joints are filled with an asphaltic filler.

The sentiment in favor of concrete pavements in Chicago is increasing. This is probably due in a large part to their economy in first cost, their pleasing appearance, their cleanliness and sanitary qualities. Their suitability as a surface material for streets with considerable traffic is a matter of considerable doubt and conjecture at present, and will require more time for its satisfactory demonstration.
VI. CONCLUSION.

(1) Average Prices in 1913.

The accompanying list of average prices for various items of pavement construction is presented through the courtesy of Mr. Julius G. Gabelman, Assistant Chief Engineer of Streets. It is shown merely as a matter of interest regarding the actual cost to the public of the various types of pavements in Chicago, and to permit of comparisons with prices obtained in other localities. The writer wishes to state, however, that these figures should not be considered of much scientific or practical value for purposes of estimating. Such figures to be of real value should be accompanied by a very comprehensive analysis of all the different factors that enter into the cost. Principal among these factors are; unit prices of materials, labor conditions and wages, local physical conditions for the several contracts, and the manner in which the bids are received for the different items in the contracts.

Under the system of constructing pavements by contract it is manifestly impossible to present an analysis of unit prices of materials due to the fact that the different contractors obtain the lowest prices and most liberal terms and discounts that they can secure and do not give cut statements of costs to the public.

As to labor conditions, a large part of the labor used in constructing pavements in this city is union labor. This labor is paid at the union scale or higher, but the number employed at various rates and the exact rate of pay is not usually obtainable.
One of the local physical conditions that affects prices is that of accessibility. If the work involves a long haul of materials it naturally costs more than if near a switch track or supply yard. Prices are also influenced by the nature of the material to be excavated and the availability of dumps upon which to waste the surplus. In some localities in the city it has been necessary to haul the excavated material to railway yards, load it upon cars and ship it out on the railroad in order to dispose of it. In other places the contractor can dispose of it along the line of the improvement, and in still others he can place it in lots or yards that are below grade and obtain a price from the owner of the property for filling in his lot. So that the conditions in these respects affect costs very materially.

The manner of receiving bids affects the contract prices also. In some cases there are items for bidding separately on the grading and certain other small details necessary to fit local conditions. In other cases such items are included in the price bid per square yard for the pavement which must be increased enough to cover the cost of these details.

The figures in the list of prices are generally averages of a great many specific items. The cost figures for certain of the little used types, though, are the results of only a very few items and show an apparent discrepancy. This is noticeable in the case of asphaltic concrete on 5 inches of slag in which the average price where the slag was rolled in 3 courses, is 5 cents lower than for rolling it in only 1 course. A similar discrepancy appears in the case of asphalt on 5 inches of concrete in which the type "B" costs 3 mills more than the standard asphalt on the same
foundation. This is due to the fact that these prices are the averages of only a comparatively few contracts. A similar reason applies to the asphaltec concrete on slag rolled in 1 course.

Any reader wishing to use these figures for purposes of comparison may find many data for various cities in the United States for the 1913 season in "Engineering and Contracting", for April 1st, 1914.

The average prices for 1914 will very likely be considerably below those given for 1913, as the bids received by the Board at the first six lettings of this year are running uniformly lower than last year, especially for asphaltec paving. The lists of average prices for pavements and appurtenances in Chicago for 1913 are shown on the following pages.
### Average Prices for Pavements in 1913

<table>
<thead>
<tr>
<th>Kind of Pavement Constructed</th>
<th>Price in Streets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asphalt</strong></td>
<td></td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>$1.778</td>
</tr>
<tr>
<td>On 5&quot; Portland Cement Concrete</td>
<td>1.630</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type &quot;B&quot; Asphalt</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>1.70</td>
</tr>
<tr>
<td>On 5&quot; Portland Cement Concrete</td>
<td>1.633</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asphalthic Concrete</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>1.528</td>
</tr>
<tr>
<td>On 5&quot; Portland Cement Concrete</td>
<td>1.370</td>
</tr>
<tr>
<td>On 6&quot; Slag, rolled in 1 course</td>
<td>1.360</td>
</tr>
<tr>
<td>On 8&quot; Slag, rolled in 2 courses</td>
<td>1.330</td>
</tr>
<tr>
<td>On 4&quot; Limestone on old Macadam</td>
<td>1.250</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asphalthic Macadam</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1/2&quot; Granite on 8&quot; Slag or Stone:</td>
<td></td>
</tr>
<tr>
<td>Rolled in 1 Course</td>
<td>1.192</td>
</tr>
<tr>
<td>Rolled in 2 Courses</td>
<td>1.290</td>
</tr>
<tr>
<td>2 1/2&quot; Limestone on 8&quot; of Slag:</td>
<td></td>
</tr>
<tr>
<td>Rolled in 1 Course</td>
<td>1.207</td>
</tr>
<tr>
<td>2 1/4&quot; Limestone on 8&quot; Portland Cement Concrete</td>
<td>1.350</td>
</tr>
<tr>
<td>2 1/2&quot; Gravel on 8&quot; Slag, rolled in 1 course</td>
<td>1.260</td>
</tr>
<tr>
<td>KIND OF PAVEMENT CONSTRUCTED</td>
<td>PRICE IN STREETS</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Brick</td>
<td></td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>$2.165</td>
</tr>
<tr>
<td>On 6&quot; Slag</td>
<td>1.570</td>
</tr>
<tr>
<td>Creosoted Wood Block</td>
<td></td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete, (4&quot;)</td>
<td>3.163</td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete, (3 1/2&quot;)</td>
<td>2.945</td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete, (4&quot;)</td>
<td>3.607</td>
</tr>
<tr>
<td>On 5&quot; Portland Cement Concrete, (3&quot;)</td>
<td>2.700</td>
</tr>
<tr>
<td>Number 1 Granite Blocks</td>
<td></td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>3.840</td>
</tr>
<tr>
<td>Number 2 Granite Blocks</td>
<td></td>
</tr>
<tr>
<td>On 6&quot; Portland Cement Concrete</td>
<td>3.750</td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td>6&quot; in 2 Courses</td>
<td>2.030</td>
</tr>
<tr>
<td>7&quot; in 1 Course</td>
<td>1.430</td>
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</tbody>
</table>
### Average Price for Curb in 1913

<table>
<thead>
<tr>
<th>Kind of Curb</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Alley Curb</td>
<td>$0.140</td>
</tr>
<tr>
<td>Granite Concrete Combined Curb and Gutter:</td>
<td></td>
</tr>
<tr>
<td>Gutter 6&quot; by 12&quot;</td>
<td>.639</td>
</tr>
<tr>
<td>Gutter 10&quot; by 9&quot;</td>
<td>.618</td>
</tr>
<tr>
<td>Gutter 5&quot; by 18&quot;</td>
<td>.564</td>
</tr>
<tr>
<td>Granite Concrete Gutter Only:</td>
<td></td>
</tr>
<tr>
<td>10&quot; by 9&quot;</td>
<td>.299</td>
</tr>
<tr>
<td>5&quot; by 18&quot;</td>
<td>.330</td>
</tr>
<tr>
<td>8&quot; by 12&quot;</td>
<td>.257</td>
</tr>
<tr>
<td>8&quot; by 30&quot;</td>
<td>.780</td>
</tr>
<tr>
<td>Gravel Concrete Combined Curb and Gutter:</td>
<td></td>
</tr>
<tr>
<td>Gutter 8&quot; by 13&quot;</td>
<td>.450</td>
</tr>
<tr>
<td>Gutter 10&quot; by 9&quot;</td>
<td>.605</td>
</tr>
<tr>
<td>Gutter 5&quot; by 18&quot;</td>
<td>.483</td>
</tr>
<tr>
<td>Gravel Concrete Gutter Only:</td>
<td></td>
</tr>
<tr>
<td>5&quot; by 18&quot;</td>
<td>.283</td>
</tr>
<tr>
<td>8&quot; by 12&quot;</td>
<td>.200</td>
</tr>
<tr>
<td>Granite Concrete Vertical Curb:</td>
<td></td>
</tr>
<tr>
<td>7&quot; by 9&quot; by 24&quot;</td>
<td>.734</td>
</tr>
<tr>
<td>7&quot; by 7&quot; by 18&quot;</td>
<td>.610</td>
</tr>
<tr>
<td>Gravel Concrete Vertical Curb, (granite finish):</td>
<td></td>
</tr>
<tr>
<td>7&quot; by 9&quot; by 24&quot;</td>
<td>.570</td>
</tr>
<tr>
<td>Sandstone Curb:</td>
<td></td>
</tr>
<tr>
<td>7&quot; by 18&quot;</td>
<td>.793</td>
</tr>
<tr>
<td>4&quot; by 24&quot;</td>
<td>.470</td>
</tr>
</tbody>
</table>
### Average Price for Cutting in 1913

<table>
<thead>
<tr>
<th>Service</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Cutting</td>
<td>$0.426</td>
</tr>
<tr>
<td>Rock Cutting</td>
<td>1.500</td>
</tr>
</tbody>
</table>

### Average Price for Cement Walks in 1913

<table>
<thead>
<tr>
<th>Service</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walks extended to curbs and patched</td>
<td>.140</td>
</tr>
</tbody>
</table>
(2) Comparison of Different Types of Pavements.

In comparing the various types of pavements laid in this city it appears that the most uniformly satisfactory results are obtained with the standard sheet-asphalt type. Consequently a greater yardage of this pavement is constructed here than of any of the other types. The asphalt pavement has been improved and developed to a point where practical uniformity in composition is a common occurrence. When properly constructed the asphalt pavement has to a high degree the essential requirements of a good pavement. For durability it may not compare with granite block pavements, but it stands very high in that respect. It is clean and sanitary and has a pleasing appearance. It has a low tractive resistance and is less noisy than brick or stone block. It has the disadvantage, however, of becoming slippery at times when the weather is such that the surface becomes wet and icy. It is easy to repair where an asphalt plant is located in the community but would not be easy to repair in a small town with no plant available.

As to cost it is shown on the list of average prices that it is a medium priced pavement. The fact that a pavement with so many desirable qualities can be laid for such a moderate price is the probable reason for the popularity of this type.

The type "B" asphalt pavement has practically the same qualities as the standard type except that it has not the thickness and consequently can not be expected to be as durable although no comparative data are available along that line. It is merely a modification of the standard type with the object of cutting the
costs. It is doubtful, though, if it is wise to commence building lighter and weaker pavements now when the advent of enormous high-speed motor trucks is causing a greater strain on them than was ever considered a few years ago. As was stated on page 72 the cost has not been reduced in proportion to the strength and depth, and the object for which this type was adopted has not been accomplished so far.

The asphaltic concrete pavement is one of the newer types that have been developed recently and seems to be still in the formative period, as different municipalities use widely varying specifications for this pavement. As it is laid by the Board of Local Improvements it has most of the qualities of the sheet asphalt and looks very much like it on the street. In fact it often requires a close examination of the surface to detect the difference. It might be described as a granite filled sheet asphalt top mixture laid without any binder. The surface presents a slightly better foothold for horses than sheet asphalt. It has been laid for an average of about 25 cents less per square yard than the sheet asphalt and where first cost is the important factor to consider it may prove to be the most advantageous pavement to construct.

The asphaltic macadam pavement is also one of the more recent developments which have been adopted in Chicago, and in many other communities, as a partial solution of the problem of securing an economical pavement to resist motor traffic. It is distinguished from the asphaltic concrete type chiefly because it contains larger stone in the aggregate and is built by the pouring or penetration system instead of by being mixed hot. It has many
of the qualities of ordinary asphalt. It is not so slippery, and when properly built it possesses greater resisting power to the rutting or pushing action of traffic than sheet asphalt or asphaltic concrete. It has the disadvantage, however, of requiring almost ideal weather conditions for its proper construction. The stone must be bone dry, and if it is moist the hot asphalt forms a sort of an emulsion and does not bond the stone. Again, if the asphalt is not distributed evenly a portion may have an excess so that the particles of stone will float in the asphaltic cement and in hot weather will push out and form ruts. On the other hand, if spots have a deficiency of the asphaltic binder the stones will ravel out and chuck holes will be formed. When properly laid, however, this type seems to give good service. Its cost, with a granite top, was only $1.19 per square yard making it the lowest priced pavement laid in this city by the Board of Local Improvements. It may be seen on the list that the granite surface costs no more than the surfaces made from cheaper stone. In the opinion of the writer the use of hard stone for the wearing surface is advisable even at a considerably higher cost\(^5\) (see pages 84 to 86). The result of local experience so far seems to promise that this type of pavement when constructed under proper conditions will offer one of the answers to the problem of a low cost pavement to resist motor traffic and take the place of the old water bound macadam pavement.

None of the asphaltic pavements are very well adapted to streets on which street car tracks are located.

Brick pavements have many of the desirable qualifications to be considered in choosing a pavement. They rank somewhat
higher than asphalt as to durability under equal conditions, and they have a low tractive resistance and afford an excellent footing for horses. But they are not as easily cleaned as the asphalt pavements, and last year they cost about 40 cents more per square yard. They are well adapted for streets with car tracks and are used extensively here on such streets. They are also built on many residence streets and give very satisfactory service. As was stated on page 76, their excellent qualities have been fully demonstrated for many years.

Granite block pavements are more durable than any of the other types laid in Chicago. They are also the most expensive in first cost. This type cost more than twice as much as sheet asphalt in 1913, and cost $1.87 per yard more than brick and an excess of 68 cents over the creosoted wood block type. This pavement also affords an excellent footing for horses and has a low resistance to traffic. It is pleasing in appearance and is as easily repaired as brick or creosoted wood block pavements. But it is more noisy and less sanitary as well as being more difficult to clean. It is seldom that number 2 blocks are specified for paving streets, number 1 blocks being used almost exclusively. The number 2 blocks are used more in alleys. The number 1 blocks are cut and dressed to a more nearly true surface than was customary several years ago which permits of narrower joints and presents a smoother surface (see pages 76 and 77). But in the course of time the blocks wear rounded until they become smooth and what is termed as "turtle backed". This condition increases tractive resistance and noise and affords less secure footing for horses so that when such conditions become aggravated the pavement is said to be worn out.
At this stage many pavements have been removed and new pavements laid. When the pavements have been torn out the old blocks have often been reused and used again as number 2 blocks. So that, while the granite block pavement has great durability its practical life depends upon the ability to resist the tendency to wear round. Of course when this pavement is used it is almost always laid on streets with very heavy traffic and the foregoing statements would apply only to pavements laid on streets with such traffic conditions.

Creosoted wood block pavements rank second in relative first cost. They are in first rank from the standpoint of noiselessness. This is the chief point of merit for this type of pavement, and where quietness is a paramount consideration, this is perhaps the best type that can be obtained. These pavements are also sanitary and somewhat antiseptic. They are about equal to asphalt in appearance and ease of cleaning, and equal brick and granite in ease of repairing openings. Its chief objections are that it sometimes becomes very slippery, and the tendency for oil or tar to exude from the fiber has not as yet been entirely overcome. The difficulty caused by expansion has been practically eliminated. This pavement gives excellent results but it is a matter of question whether the extra expense of building it is justified except in cases where the need of quietness is of such supreme importance as to overbalance other requirements. See pages 78 to 83 for the description of this pavement.

Concrete pavements are described on pages 86 to 89. They are increasing in popularity in many communities. This type when in good condition is clean, sanitary and pleasing in appearance.
It offers low resistance to traffic and affords a fairly good foothold for horses. It costs according to our list of average prices for 1913, for a 7" course of concrete about 35 cents per yard less than standard sheet asphalt on streets; but since it was laid in alleys only, it probably cost more than the same material would cost on a street. For this reason we should compare it with its chief competitor, brick. Last year it cost 88 cents less than brick in alleys. These pavements have given fairly good results in Chicago in alleys but have not a very good record on streets. Of course the causes of failure were not built exactly according to the same requirements that the present practice follows, but the difference is not excessive. The chief defect is that cracks develop and become greater under the traffic as time passes so that the concrete is broken adjoining these cracks. The tendency to crack does not seem as great in the narrow alley pavements with their light traffic, but even here it is present to a certain extent. The traffic in alleys is not severe enough to cause very much disintegration at these cracks and so the results are fairly good. The writer is of the opinion, however, that this pavement should not be laid very extensively on city streets until it has had a thorough trial as it is now built under the new specifications, and has demonstrated its suitability for such use, a good deal more thoroughly than it has up to date.

The foregoing discussion of the various types of pavements is based merely on the opinions of the writer resulting from his experience as an employee of the Board of Local Improvements, combined with observation of the experiences of his associates. Since these opportunities for observation have been
limited to paving practice and results in the City of Chicago only, it should be borne in mind by the reader that the statements regarding paving practice and costs, and the comparisons of different pavements, while usually applicable in this city, cannot always be applied here because special cases arise that do not harmonize with them. Consequently they are even less apt to be directly applicable to cases in other cities and towns where the conditions are different from those in Chicago. The preceding discussion is not intended to be applied directly to individual cases, but it is hoped that by furnishing information regarding the practice in Chicago, for comparison with similar information from other localities, that some additional light may be shed on the vast problem of paving the streets in the cities of the United States.