# USE OF ASPHALT AS A FILLER FOR BRICK PAVEMENTS

Thesis for the Degree of B. S.

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# THE USE OF ASPHALT AS A FILLER FOR BRICK PAVEMENTS

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CONTENTS


| | Page |
|---|---|
| Acknowledgment | 1 |
| A brief history of the use of asphalt | 2 |
| Purpose of this thesis | 4 |
| A comparison of the three main types of filler used | 5 |
| Observations of Ohio State Highway Test Section | 9 |
| Devices used for application of filler | 11 |
| Preparation of the test section | 13 |
| Description of apparatus used | 15 |
| Data of tests performed | 21 |
| Results of tests | 23 |
| Conclusions drawn from tests | 29 |
| Conclusion | 31 |

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Much of the success of this thesis has been due to their efforts and I hereby thank them again for the interest which they have taken.

A BRIEF HISTORY OF THE USE OF ASPHALT.

The use of asphalt can be traced as far back as 3000 B.C. to the pre-Babylonian inhabitants of the Euphrates valley. These people, known as the Sumerians, were skilled in carving and decorating stone, and in the making of their statues asphalt was used to cement the eye-sockets in place.

The early Egyptians used the asphalts for preserving their dead rulers, by wrapping the bodies in cloth and coating them with liquid or melted asphalt. These preserved bodies are known as mummies, and at one time the words "asphalt" and "mummies" were synonymous.

The Babylonians also used the asphalt as a means of holding brick to-gether in the building of walls around castles and cities. They also used the asphalt-filled brick pavements and it seems peculiar but the idea was not tried again until late in the nineteenth century when stone-block pavements were constructed using asphalt as a filler. There are still examples of t the Babylonian brick pavements still clinging firmly to-gether.

And so on to the present time asphalt has been used to a great extent and for a variety of purposes. In 1917, 1,586,105 tons of asphalt were used in the United States.

Thecchief use of ashalt at present is for road building purposes, that is for, Sheet asphalt pavements, asphalt-block pavements, bituminous macadam, bituminous dust-laying oils, filler for joints, and filler for brick, stone-block, and wood-

block pavements.

Asphalt is also used quite extensively in construction work for, asphalt mastic flooring, roofing fabrics, water proofing, sheathing, and insulating purposes. More and more is being used every year indicating its importance in modern industry.

PURPOSE OF THIS THESIS.

The purpose of this thesis is to determine the effect of heating the brick prior to filling the openings with the asphalt filler. A comparison of the pre-heated brick and the cold-poured brick will be made, as to, effect of penetration of the filler into the openings, adhesion of filler to the sides of the brick, ease of application of the filler, surplus of filler left on the surface, and the amount required to pour the section.

A COMPARISON OF THE THREE MAIN TYPES OF FILLER USED.

There are three main types of filler which have been used for brick pavements namely, sand, cement grout, and asphalt. The only purpose for which the sand was used,it seems, was to fill up the small openings between the bricks in order that the brick would not shift, The sand did not even serve this purpose adequately as the traffic passing over the brick jarred the brick to such an extent as to force the sand out of the cracks, the wind then blowing it away. It was also discovered that a substance was needed which would prevent the water from running down between the bricks for water underneath the bricks would freeze and cause the brick to heave and ruin the pavement. Cement grout was tried and seems to have served its purpose in a few cases as can be seen from an inspection of some of the grout filled pavements ten to twenty-five years old. These cases are rare however, for most of the grout filled pavements show many bad spots along their route. The cause ofvthis failure can be traced directly to the expansion and contaction due to changes in temperature. From an inspection of a group of grout filled pavements I have noticed that there is a tendancy for the pavement to buckle or pile up at some point or points. At Howell Michigan, for instance, the grout filled brick pavement buckles at the three streeet intersections from a distance this appears as though it is simply the crown of the intersecting streets but upon close inspection it will be found that considerable buckling has taken place. There are numerous cases identical to the one at Howell, Plymouth, Detroit, Ypsilanti, and Ann Arbor all have existing examples of buck-

ling. This buckling naturally leaves a bump and also causes the grout to crack away from the brick, allowing water to seep down to the subgrade and again heaving is obtained by frost action.

An interesting method of using grout filler came to my attention while at Columbus, Ohio. The method consisted of laying about four hundred feet of grout filled pavement and then laying a strip of fifty feet of asphalt filled brick. The strip of asphalt filled brick being layed to take care of the expansion and contraction due to temperature changes. All of the modern layed brick pavements, that is, the section between car tracks, are built this way in the state of Ohio. It seems to be a method which could be used successfully for brick pavements in cases where the engineer insists on using the grout filled type.

At the present time the use of asphalt as a filler has become very prominent. The pliability of asphalt allows for expansion and contraction and it also serves its purpose of making the joints water tight. Up to the present time there is one objection to the use of asphalt filler, however, and this is the trouble undergone with the application of the filler to the brick. Due to contraction upon cooling the filler recedes into the spaces between the brick leaving the space only partially filled. A second application is therefore necessary and with the second application a surplus of filler is always left on top of the brick. Of course this surplus varies and if extra care is taken it can be

cut down to some extent but not entirely eliminated. There are two big objections to the surplus, first it leaves the road in a very slippery condition. One section of asphalt brick pavement near Columbus, Ohio, for instance, has large signs erected along its route stating "Danger, this road very slippery when wet." There a surplus of asphalt filler is noticeable and numerous accidents have resulted with a loss of several lives within the last year. The second objection is that the traffic passing over a section of pavement having a surplus of filler will pick up the surplus and deposit it in blotches or bumps on the road. There are two main objections to the picking up of the filler. When the filler is picked up either a part or all of the filler is drawn out of the cracks and its chief purpose taken away, for water will seep in and cause frost action to heave the pavement. This condition was readily noticeable along the over filled section at Columbus. The second objection is the forming of the blotches, for in time a bump will build up and the trucks passing over this bump will break the pavement. A rough spot soon developes and the water can also seep through and cause heaving.

The relative cost of grout and asphalt filled pavement show asphalt to be the cheaper. Some seem to think that the added cost of heating the filler makes the cost of asphalt greater but they forget that the grout must also be prepared before it can be applied to the brick.

Not only its effectiveness as a filler but also its sal-

vage value must be considered in choosing a filler. In most cases grout filled brick have a very low salvage value while the asphalt filled brick can be readily cleaned and relaid for another pavement if desired.

Often times a crack will appear in the pavement after a year of traffic, due to stresses in the base, this can remidied readily by taking up two or three layers of brick, filling the crack in the base, and relaying the brick. Practically no disagreeable hindrance to traffic is encountered. With grout filled brick the job would be a much greater one.

Another decided advantage with the use of asphalt filler is that the traffic can drive over the road two or three hours after it has been poured. With grout ten days is most generally allowed for the grout to set. Flint, Michigan layed a section of asphalt filled brick pavement through the center of the city during the summer of 1928 and in this case it was necessary to have the road open as soon as possible. Asphalt filler added greatly in the solution of this problem.

OBSERVATIONS OF OHIO STATE HIGHWAY TEST SECTION.

During the course of the summer of 1928 the Ohio State Highway Department built five and one-half miles of brick pavement using only one application of asphalt filler in order to find out if one application would suffice. The laying of this section was completed August 2, 1928. I inspected the section March 28, 1929 which means the pavement had been subjected to traffic for eight months, hardly a long enough period to show true results and yet it had been subjected to all of the seasons. Following are the conclusions which I have come to in regard to the section. On March 28th, the filler was one-quarter inch from the top of the brick which means that during the hotter weather it will probably be one-eighth inch at the closest to the surface of the brick. The question is " Will the brick spall at the edges when subjected to the heavy summer traffic? " I believe they will and think it necessary for the cracks to be entirely filled at all times. During the time the road had been subjected to the traffic spalling had not taken place to any extent but the period was mainly during the winter months during which time the traffic is decidedly less then during the summer months. If, however, the cracks would be filled to the top during the summer months the ideal condition would be reached. Of course in winter the filler would contact and recede perhaps one-eighth to three-sixteenths inches but the traffic decreases in the winter and also the snow and ice will fill up the remaing openongs and thereby protect the bricks from spalling. It seems therefore the ideal to strive for is to fill the bricks so that they will

be completely protected both in winter and in summer with no surplus accuring at any time.

It seems, therefore, unless after more time has elapsed the conditions change, that one application will not suffice for asphalt filler. Extra care was perhaps even taken in the laying of this section and therefore,under ordinary conditions of working, results as good as these would not be obtained.

Nine types of bituminous filler were used in thevlaying of the test section. Five of these were asphalt fillers, Standard F-1, Pioneer F-1, Asphalt penetration 61 to 70, Standard A-1, and Standard A-2. No noticeable difference in the application of the five was noticed according to Russell Levering, special engineer assigned to the job. Also at the time of my observation no difference was noticeable between the different fillers. This seems to indicate that the important point is not in the type of filler used, that is, within certain limits of consistency, but the chief difficulty is in the application of the filler.

DEVICES USED FOR APPLICATION OF FILLER.

There have been several devices used for the application of the filler. The first device was a cone-shaped vessel having at the point a cast-iron tip with an opening about 1/4 inches in diameter. The pouring can is drawn along the crack between the rows of brick, the point resting in the crack. The opening in the point is controlled by means of a valve with a handle conveniently arranged so that the flow of the material can be adjusted. As the vessel is drawn along, the material is allowed to flow into the joints in sufficient quantity to fill them. A helper replenishes the supply in the pouring can from time to time so that the opening pours forth a continual stream. Recently there have been developed multiple pouring cans with multiple spouts which pour several joints at a time. These are mounted on wheels and are drawn across the pavement with each of the points in a joint between two rows of brick. A steering device attached to the point serves to retain it in the joint.

The high labor cost of filling the joints by means of the pouring can has led to the general adoption of a less expensive method, namely, the squeegee method, altough the pouring can method is still used to some extent.

In the squeegee method the hot filler is poured onto the surface from pails and then worked into the joints by means of long handled squeegees. It is impossible to scrape allof the filler from the surface by this method as has already been cited. The squeegee is similar to a rake having a piece of belting about four inches wide, or some similar material, attached at the end to push the asphalt forward and into the

openings between the bricks.

Recently a sqeegee bucket has been invented, this is a square bucket holding about fifty pounds of asphalt. The bucket is mounted on two wheels and at the front there is a semi-circular piece of rubber attached to the bottom of the bucket. A three-quarter inch hole in the bottom of the bucket is controlled by a rod extending up to the handle of the apparatus. The bucket is filled and then pulled along the pavement the valve being opened sufficiently to allow the right amount of asphalt to escape. The semi-circular piece of rubber mounted at the front sqeegees the filler into the openings.

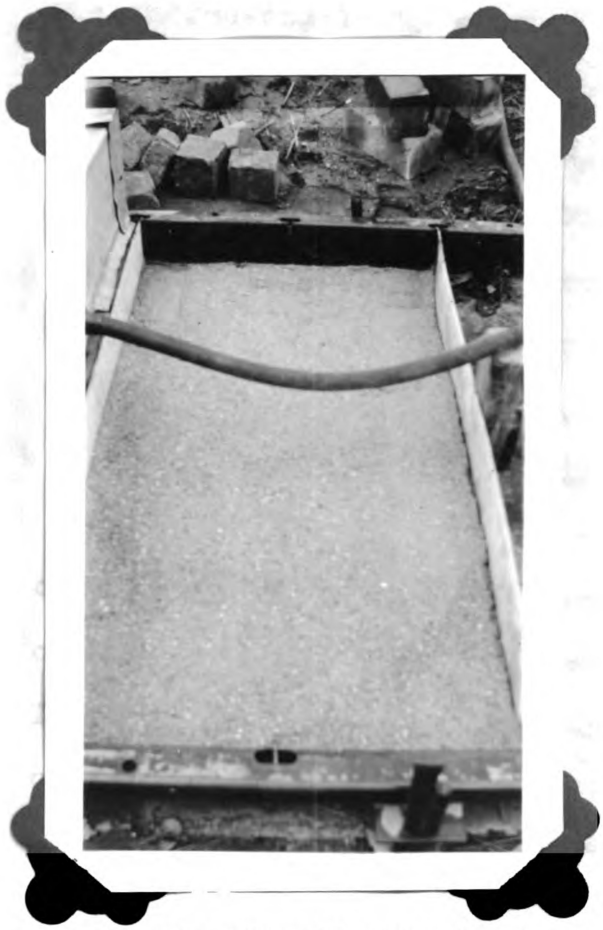
There have been many different squeegees used but they all resemble the ones described except for minor details.

The squeegee bucket seems to be alright if extra care is taken in application but in many cases it has not proven satisfactory. The engineer of the Ohio State test road stated that considerable difficulty was experienced in using the squeegee bucket.

PREPARATION OF THE TEST SECTION.

The base was prepared by leveling off a section of ground ten feet long and four feet wide. Two ordinary steel sidewalk forms were then erected, one on each side of this section, and firmly pinned in place. The earth within the forms was then leveled off so it was four and three quarters inches below the top of the forms and was then thoroughly compacted. The ground was then left exposed to the sun for three days to allow it to dry out and also to cake it to a firm base.

Three quarters of an inch of sand was placed on top of the base and leveled off with a template. The bricks were then placed on the sand with the proper spacing between them and firmly pressed into the sand in order that a smooth surface would be obtained. The section was then ready for the application of the filler.



VIEW OF SECTION WITH SAND CUSHION IN PLACE.

VIEW OF SECTION WITH BRICK IN PLACE READY FOR POURING.

DESCRIPTION OF APPARATUS USED.

A thermo-couple was used to determine the temperature of the brick section while the heating was taking place. The thermo-couple is made up of an iron wire and a constantine wire composed of a mixture of two alloys, connected or soldered together at one end, the other being connected to a scale reading in degrees Fahrenheit. The wires were bent at an angle of 90° and placed down in one of the openings between the bricks and thereby recorded the temperature of the brick below the surface.

THE BURNER

The burner was made by connecting four pieces of one and one-half inch pipe in the form of a rectangle and in one side of the rectangele,midway between the ends, a T was placed. Into This T another piece of one and one-half inch pipe was connected. The gas was brought into this pipe by means of a one-half inch rubber hose connected to the gas main. The end of the hose was inserted into the pipe and the excess opening covered with a piece of rubber tubing around the hose and over the end of the pipe. Holes were drilled every two inches along the bottom of the burner with a 1/8 inch drill to allow the gas to escape and form the flames.

THE HOOD

The hood was made of sheet metal, one strip being bent to form the top and ends and a strip riveted to each side. A slot, two inches wide, was cut from the bottom up in the center of one side of the hood. This slot allowed the hose to be

connected to the burner.

## THE STANDARD

The standard upon which the burner was placed consisted of a strip of 1/8 inch steel one inch wide bent U-shaped and placed eight inches from a similar strip. These two strips were held in place by two cross braces of the same material. When the burner was placed on top of the standard it was four inches from the surface of the brick.

## THE SQUEEGEE MOP

The squeegee mop was entirely used in the construction of the test sections, as the sections were too small for the squeegee bucket. A description of the squeegee mop is given in another part of this thesis.

## THE ASPHALT

An asphalt manufactured by the Dowd Chemical Company was used as a filler. Three tests were made to determine the specific gravity, the penetration, and the flash point of this asphalt with the following results:-

Specific Gravity-------- .938

Penetration---------- 70

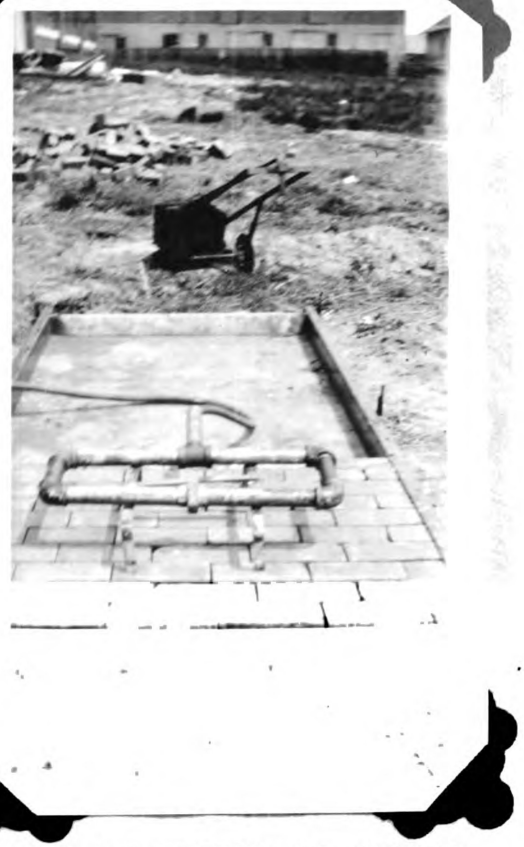
Flash Point---------- 520° F.

The asphalt was heated by means of a cylindrical burner connected to the gas main leading to the heating apparatus. A twenty-quart pail made of heavy steel was used to heat the asphalt in.

## THE BRICK

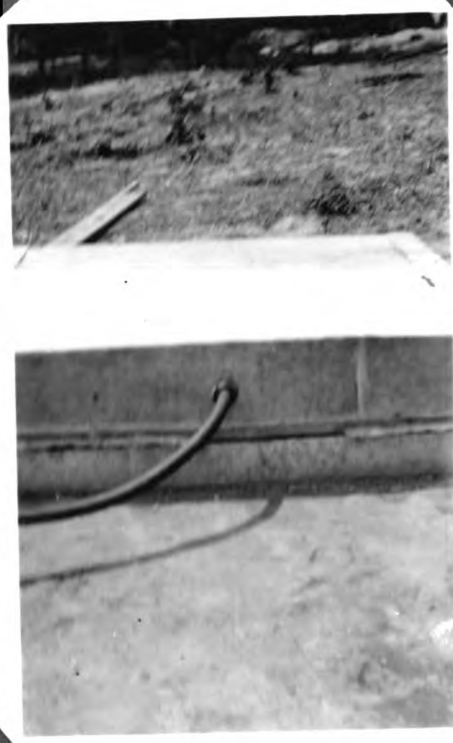
8" x 3-1/2" x 4" straight wire-cut brick were used for all

of the sections. It can be seen that if good penetration is obtained with this larger type brick it will be insured when using the smaller type of brick.

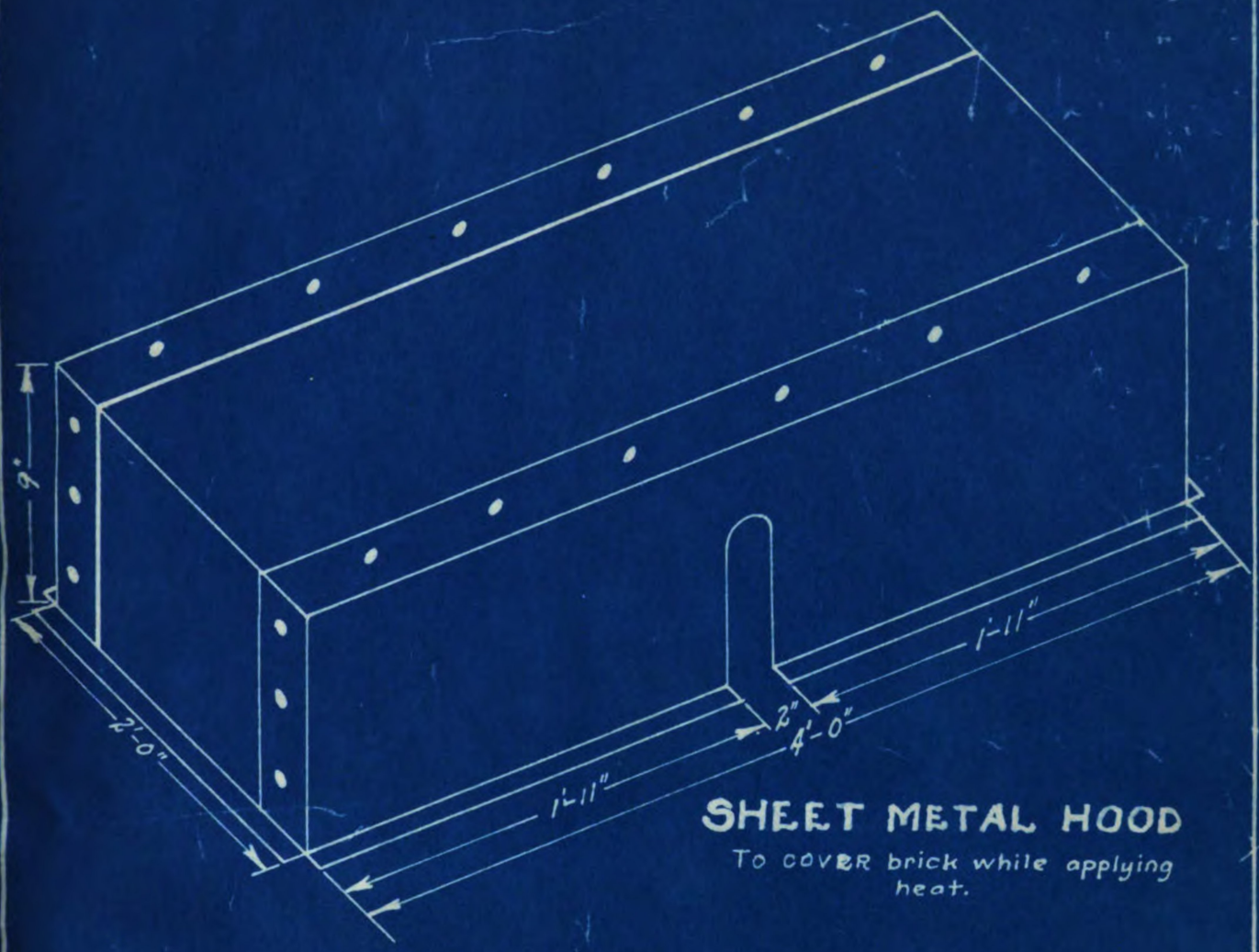


VIEW OF BURNER AS PLACED ON BRICK

THE ASPHALT HEATING APPARATUS

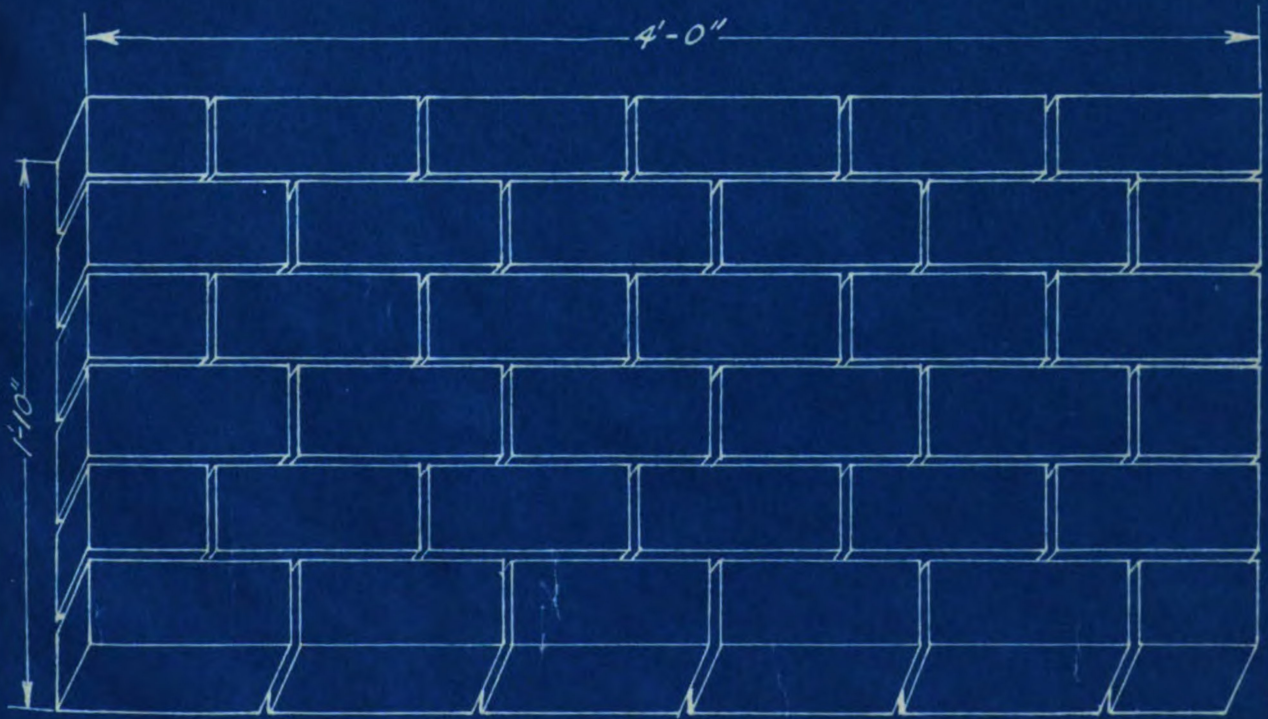


VIEW OF SECTION COVERED WITH HOOD.
PROCESS OF PRE-HEATING THE BRICKS.

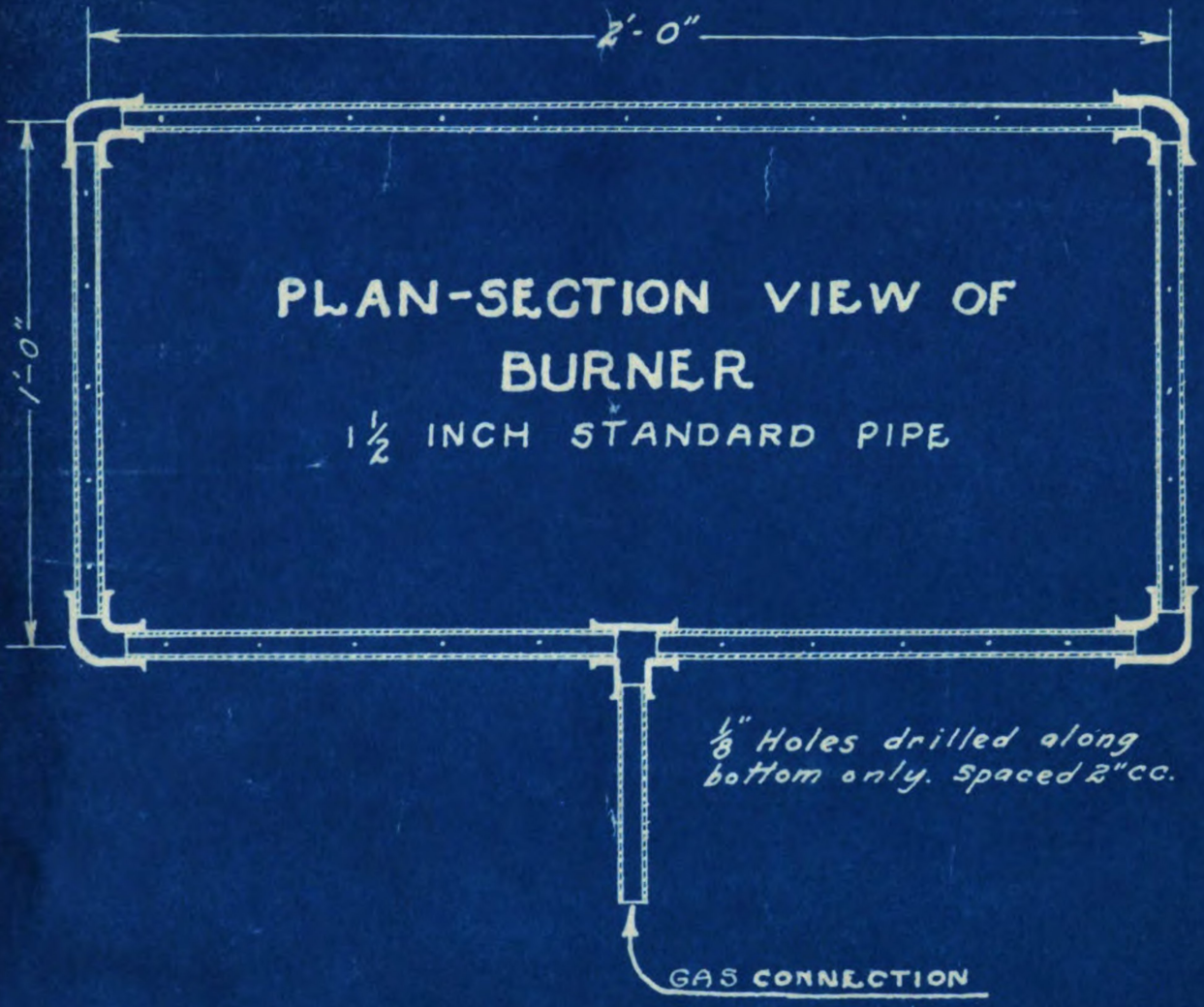


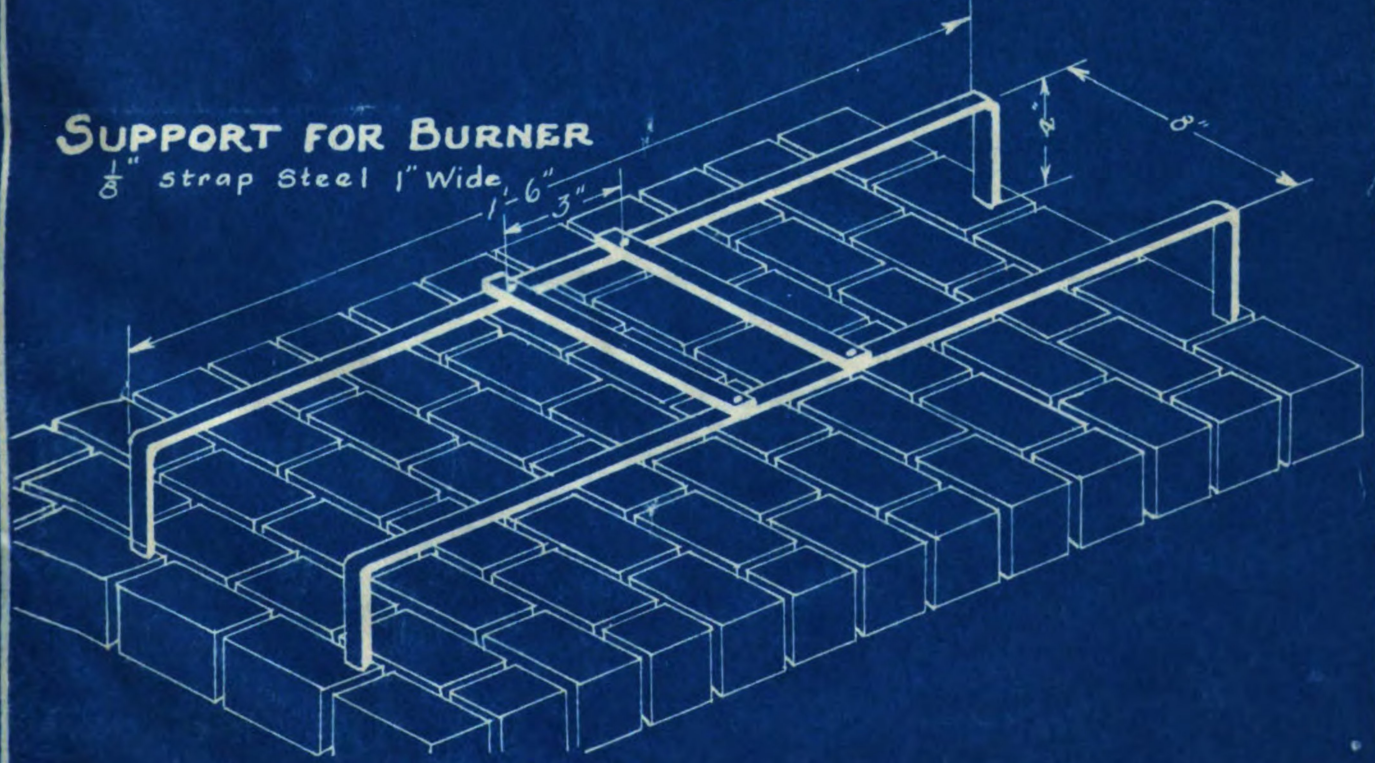

## SHEET METAL HOOD

To cover brick while applying heat.




## TYPICAL TEST SECTION


2'-0"
1'-0"
PLAN-SECTION VIEW OF
BURNER
1½ INCH STANDARD PIPE
⅛" Holes drilled along
bottom only. Spaced 2"cc.
GAS CONNECTION


SUPPORT FOR BURNER
⅛" Strap Steel 1" Wide
1'-6"
3"
8"

DATA OF TESTS PERFORMED.

TEST NUMBER 1

Temperature of the Air---------- 75° F.

Temperature of the Bricks----------300° F.

Temperature of the Asphalt----------300° F.

Amount of Asphalt Used---------- 12 lb.

This section was 3'x 4' and therefore an insufficient amount of asphalt was ready for application. The filler only filled the openings to within one inch of the top or about three-quarters full.

TEST NUMBER 2

First Application

Temperature of the Air---------- 82° F.

Temperature of the Bricks----------550° F.

Temperature of the Asphalt----------300° F.

Amount of Asphalt Used.----------7-1/2 lb.

Second Application

Temperature of the Air---------- 54° F.

Temperature of the Bricks----------200° F.

Temperature of the Asphalt----------300° F.

Amount of Asphalt Used for Entire Section--------- 11 lb.

The section was heated far too high in the first place as upon application of the filler it bubbled and boiled for nearly an hour after application, and due to this bubbling it was impossible to put enough asphalt on the section to fill the cracks as it would boil on to thecsurface as fast as it was applied.

TEST NUMBER 3

Temperature of the Air---------- 77° F.

Temperature of the Bricks---------- 200° F.

Temperature of the Asphalt---------- 300° F.

Amount of Asphalt Used---------- 11 lb.

This section was used mostly in the comparisons set forth later in this thesis.

TEST NUMBER 4

Temperature of the Air----------= 54° F.

Temperature of the Bricks---------- 54° F.

Temperature of the Asphalt---------- 300° F.

Amount of Asphalt Used ---------- 13 lb.

In this section the brick were not heated and the asphalt squeegeed much harder.

TEST NUMBER 5

Temperature of the Air---------- 77° F.

Temperature of the Bricks---------- 77° F.

Temperature of the Asphalt----------350° F.

Amount of Asphalt Used---------- 14 lb.

The bricks were not heated in this section but the air temperature was higher then that in the previous test and the asphalt was heated to a higher temperature. This section was a little easier to squeegee then the previous one. A comparison was made using this section as the cold brick section as it showed the best results of the two cold brick sections.

RESULTS OF TESTS.

## EASE OF APPLICATION

The difference in the ease of application was readily noticeable between the pre-heated section and the cold brick section. It is easy to see that when hot asphalt comes in contact with the cold surface of the brick it will cool readily, forming a gummy mass which interferes greatly with the squeegee mop. After two or three minutes it was nearly impossible to squeegee this gummy mass, and remove the surplus asphalt from the surface. While with the brick at nearly the temperature of the asphalt it was an easy matter to squeegee the filler back and forth from four to six minutes. This serves a dual purpose, first it allows the surface to be cleaned of excess filler, and second, it allows all of the joints to be thoroughly filled. We must also consider the saving of energy of the squeegee men, for, if a man does not have to work so hard to squeegee one yard he can cover a larger area in one day, This means more brick layed per man per day.

## EXCESS OF FILLER ON TOP

The excess of asphalt was much more noticeable on top of the sections which had been cold poured then on those with which the brick had been pre-heated. On the cold poured sections there was an eighth inch surplus on many of the brick while the only surplus left on the pre-heated brick consisted of a thin film which the squeegee mop would not remove. The film was so thin that it was difficult, or rather nearly impossible to remove, while with the cold brick one could start at one end of the

brick and peel off blotches of the filler with little difficulty.

## STRENGTH OF SECTION.

After the sections had been in place for twenty-four hours they were removed from the forms. In removing them a piece of of pipe was forced under the section and the section pried out of the forms. With the pre-heated brick section, the entire piece came out intact showing the great strength of the section as a whole. The cold poured brick came out in small sections of from two to five brick only.

## PENETRATION.

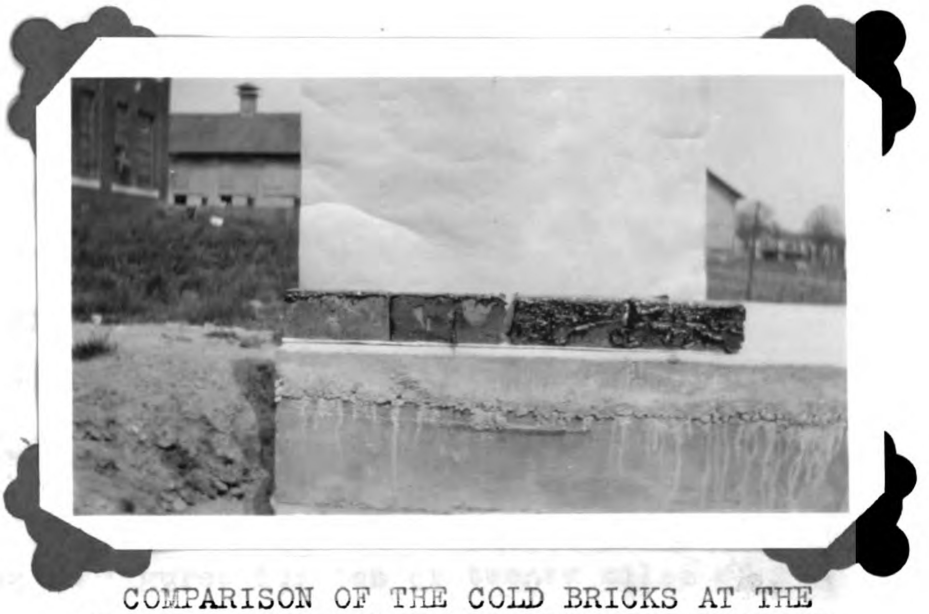
After the sections had been removed from the forms the bottom was inspected to compare the penetration of the filler into the openings. With the pre-heated section absolute uniformity of penetration entirely to the bottom of the brick was obtained. AS a whole most of the cold poured brick were filled to the bottom but the uniformity of the preOheated section was lacking.

## BOND

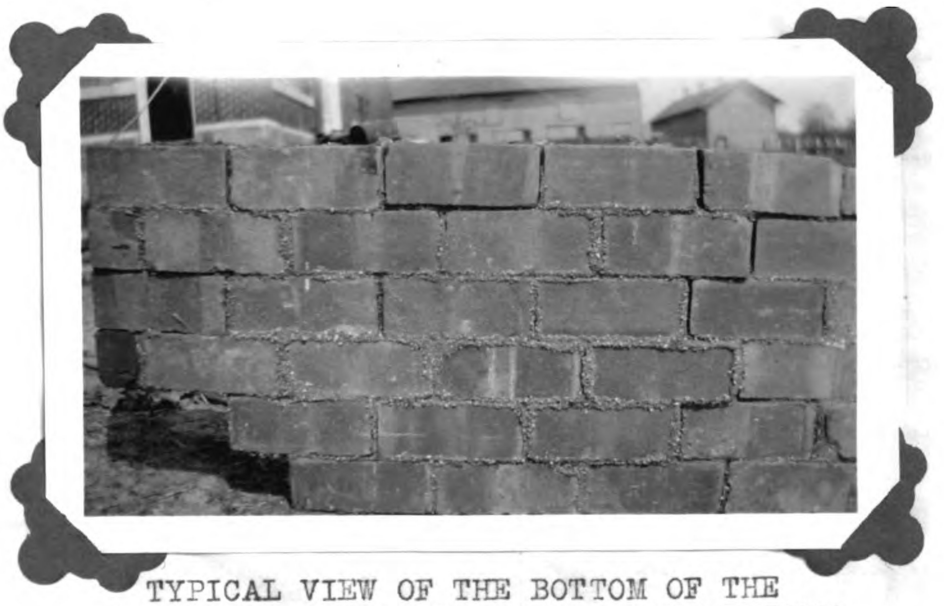
The bricks were next pried apart and the bond compared. In pulling two cold poured brick apart one face of the brick was left entirely clean while the other brick held all of the filler. The filler could readily be peeled from the brick to which it had adheared leaving its surface as clean as it was prior to pouring. When the pre-heated brick were pried apart the asphalt parted about midway between the brick leaving both surfaces covered with the filler and it was extremely difficult to remove. Even after the asphalt had been removed small particles were found in the pores of the brick.

TYPICAL VIEW OF COLD-BRICK SECTION
SHOWING TWO BRICKS WHICH HAVE BEEN PULLED APART
(Note clean surface of brick at the left and the entire filler clinging to the brick at the right)

TYPICAL VIEW OF PRE-HEATED SECTION
SHOWING TWO BRICKS WHICH HAVE BEEN PULLED APART
(Note asphalt clinging to both brick and stringy effect indicating the force necessary to pull the brick apart)



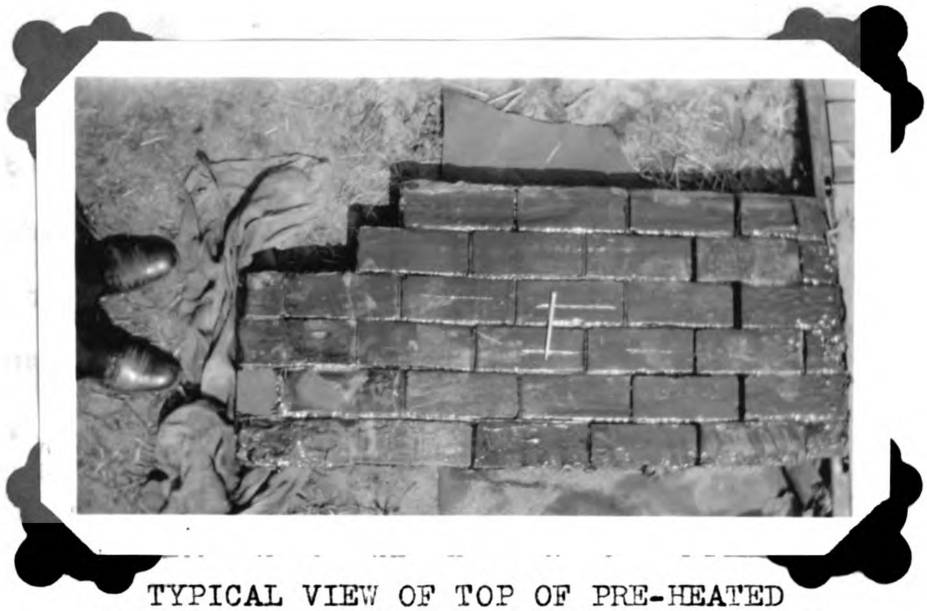
COMPARISON OF THE COLD BRICKS AT THE
LEFT AND PRE-HEATED BRICKS AT THE RIGHT



TYPICAL VIEW OF THE BOTTOM OF THE
PRE-HEATED SECTION, SHOWING THE UNIFORM
PENETRATION OBTAINED

## AMOUNT OF ASPHALT USED

The amount of asphalt used to pour each section was carefully recorded. It can be seen from the chart of data that 13-1/3 pounds of asphalt were used for the cold brick sections, while only 11 pounds were needed for the pre-heated sections. The only place this can be accounted for is in the surplus left on top of the brick. A saving of 2.8 pounds of asphalt per sqware yard of pavement is accomplished by pre-heating the brick, quite a saving if figured for ten or twentv miles of road. A saving of approximately $175 per mile of twenty foot road.



TYPICAL VIEW OF TOP OF PRE-HEATED SECTION. SURPLUS NOT VERY NOTICEABLE.

VIEW SHOWING PART OF PRE-HEATED SECTION PRIED APART. NOTE THE PERFECT BOND OBTAINED.

CONCLUSIONS DRAWN FROM TESTS.

It can be readily seen that a decided advantage is gained by pre-heating the brick. In the first place it is easier to apply, thereby a gain is made in output of the workmen. Also a cleaner surface is left after the application is completed. Second, the excess of filler left on top of the brick is nearly entirely eliminated thereby getting rid of the disadvantage of the filler picking up and drawing the filler out from between the brick. Third, perfect bond is obtained between the brick and the filler. This has two advantages. If there is an excess left due to poor workmanship, and if the traffic does tend to pick up the excess, it will yet be next to impossible to draw the filler out from between the bricks due to the perfect bond present. There is absolutely no chance for the water to seep in between the brick and the filler for, the filler and the brick are as one body thoroughly bonded together. Fouth, penetration is uniform leaving not a single opening for the water to seep in and cause heaving by frost action. With the cold-poured section there were a few bricks which had not been entirely filled. Fifth, as has been stated before, a saving of 2.8 pounds of asphalt per square yard of pavement was found to result from pre-heating the brick and this saving alone would evidence enough of the practical side of the method.

It is only necessary to heat the brick to 200° Fahrenheit, 12° below the boiling point of water. A surface burner could no doubt be used to secure this temperature with little difficulty. A burner of this type is now being used in some cases

to dry the brick if they have become damp prior to filling.

The cost involved in the heating of the brick would be more then made up by the saving in asphalt and in the increase which each squeegee man could lay per day.

There is onlv one precaution necessary, and this would probably never occur, DO NOT HEAT THE BRICK TOO HOT for the asphalt will be heated high enough to bubble and boil and hinder the filling of the openings, for, it is impossible to ascertain how full the cracks are while the bubbling is taking place.

## CONCLUSION

In concluding I wish to state that the pre-heated section has proven itself to be far superior in all of the points for which it was investigated. It has also proven practicle on a small scale and I believe it would prove to be a practicle improvement in the laying of brick pavements.