PUBLIC ROADS :

THEIR CONSTRUCTION AND MAINTAINENCE .

ALSO

THE EFFECT OF AUTOMOBILE TRAFFIC ON THEM.

Respectfully submitted to

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PUBLIC ROAD CONSTRUCTION.

Perhaps never before has there been such concerted and well directed action by the people of our country in the interests od better roads than there has been within the past year or two. The advent of the motor car may be credited with a large part of this interest, for motor cars need good roads to travel over and at the same time are a serious detriment to good roads already in existence. Individual States have taken up the policy of the National Government in building roads and many miles of first class roads are building at the present time.

The great "National Highway" which was christened last fall by a parade of about sixty automobiles travelling from New York City to Atlanta was a forerunner of the movement for good roads which will soon be started throughout the South. These automobilists made permanent record of the condition of the roads passed over and gave out a statement as to which portions were best for travel. This will put the different states in a position of friendly rivalry and good roads are bound to be the result of the movement.

It is quite natural and to be expected that different sections of a country would be better fitted to build different kinds of roads. It shall be the purpose of this paper to give a brief outline of several kinds of roads, their construction and maintainence on the most economical basis, and finally to cite some of the injurious effects of motor cars and the possible methods of overcoming them.

SAND-CLAY ROADS.

Some localities are peculiarly fitted to build one kind of road and maintain it on a much more economical basis than any other kind. For instance, in the South there are many places where clay roads are already in ex-

istence doing comparatively good service, the only need being some material to put with the clay which will overcome its sticky quality and other objectionable features. Sand has been tried and with marked success in many places. It is a well known fact that sand lacks binding power. It is the final result of the grinding and rubbing of silica rocks on one another and contains no material which will bind. On the other hand, clay is formed by the decomposition of other materials or minerals which go to make up the structure of rocks. The origin of all clay is the mineral feldspar, which under the action of water has been gradually leached out and turned into clay. The particles of clay are as a ru e much finer than sand and are frequently carried by running water long distances.

With respect to its use on roads clay must be examined from two aspects: viz:- Its plasticity and its property of slaking when it first becomes wet after having been uncovered. A clay which becomes sticky or rolls up in lumps or balls on becoming wet is "plastic clay". A lump of such clay will hold its shape for a considerable length of time if immersed in water. The other kind of clay, however, will fall to pieces immediately as a piece of quicklime would do under similar conditions. It is readily seen that this slaking characteristic is an important one from the standpoint of road-building, for a road of this material will not become sticky during a wet season but the clay will slake and form a thick mud like a viscuous liquid and become very disagreeable to travellers. This clay, of course, is more easily mixed with any other substance than the plastic clay as it will not stick to the mixing tools and is more easily handled as a result.

The proper mixing of the sand and clay will be next considered. The best sand-clay road is one in which the wearing surface is composed of g grains of sand in contact in such a way that the voids or angular spaces between

the grains are entirely filled with clay, which acts as a binder. Any excess of clay near the surface above the amount necessary to fill the voids is detrimental. If an insufficient amount of sand is used, the grains of sand will not be in contact as they should be and will be free to move, consequently there will be no more resistance to pressure than if the mixture consisted of clay alone. On the other hand, if the mixture contains an insufficient amount of clay it will lack binding power and will soon disintegrate. In a section where a sand-clay road is to be built it will be readily evident that the most economical method will be to haul the sand and not the clay to the road bed, for the clay would be difficult to dig and would be in lumps which are apt to remain unbroken on the roadbed unless great care is taken in mixing. Assuming that the sand is to be brought to the roadbed and scattered over the road, the next step is the mixing. Several inches of sand should be spread over the road and then plowed under and the whole thoroughly harrowed by a disc harrow. This is the most laborious part of the building of a sand-clay road but it is the only way of obtaining a proper mixture. In some cases the mixture may be left to traffic but this is only done where money is not available for the plowing and harrowing. In the use of a slaking clay much less puddling and mixing is sufficient as when wet the material will mix to a great extent of its own accord under the influence of traffic.

One method of obtaining the percentage of sand to use is by taking a glass of sand and one of water and pouring the water into the sand until the glass is even full of sand and water. The percentage of water the glass will hold may be calculated and this will be approximately the measure of the voids in the sand to be filled by the clay.

DRAINAGE: Possibly the most important consideration in the construction of any road is proper drainage conditions. If natural drainage does not exist artificial methods must be used. If the road is high and the soil beneath of such a nature that rain water will be absorbed quickly, no great attention need be paid to this subject, but in some sections where rainfall is very heavy and the roadbed is low roads are continually wet and muddy as a result. If such conditions be met it is necessary to raise the bed to a crown and dig wide ditches on each side before any material is hauled upon it. A good method is to begin a section nearest the source of the clay first and haul the succeeding loads over the first ones, the construction wagons thus furnishing the means of puddling or mixing. After the surface has been smoothed and covered with sand traffic should be encouraged and advantage should be taken of rains to use the harrow to thoroughly mix the sand and clay until there is practically no tendency to "ball" or cake, more sand being added from time to time as required by the condition of the bed. The quantity of clay required to build a mile of road will vary of course with the width and depth of the clay layer. A roadway twelve feet wide with an average depth of six inches will require one cubic yard of clay to one and one-half running yards of road length, or about 1175 yards of clay will construct one mile of road on a sand foundation. From this data the cost of construction of a sand-clay road may easily be estimated.

CLAY SUBSOIL: The drainage having been properly looked after the clay subsoil should be crowned as nearly as possible to the form desired in the finished road. The road surface should slope from the center to the sides at least a half inch to the foot. The surface should now be plowed and harrowed to a depth of about four inches until the clay is ground and pulverized as much as possible and then six or eight inches of sand spread upon it.

These should now be mixed as thoroughly as possible while still in a comparatively dry state. After the first mixing the road is usually puddled with a harrow after a rain. In case an excess of clay works to the surface more sand should be applied until this trouble is overcome. The road should be opened to traffic as soon as possible after completion as this will be found to have a beneficial effect upon it. Definite statements as to the cost of sand-clay roads cannot be made, as local conditions must be taken into consideration in every such estimate, but the result of experience seems to indicate that good sand-clay roads can be built at a cost of from between $300 and $800a mile according to conditions. There is therefore no question but that this form of construction is very much cheaper than macadam under all circumstances.

BURNT-CLAY ROADS.

In many large areas in the South the clays are of a sedimentary nature and practically no sand is to be found locally. The cost of bringing sand from a distance for road building would be far too much to admit of it as an important element. Some other methods must be devised therefore to meet the conditions in these districts. These clays are nearly all of the sticky plastic nature spoken of before, and, before treatment of any kind is given them, heavy traffic in wet seasons is practically impossible. The Office of Public Roads has conducted a number of experiments on this clay to determine what could be done in the way of burning or clinkering it so as not only to destroy its plastic quality but also to form hard brick-like lumps which should be capable of sustaining traffic. These experiments were remarkably successful and the clinkering point of the clay was found to be sufficiently low to indicate that the simple burning of the clay upon the road surface

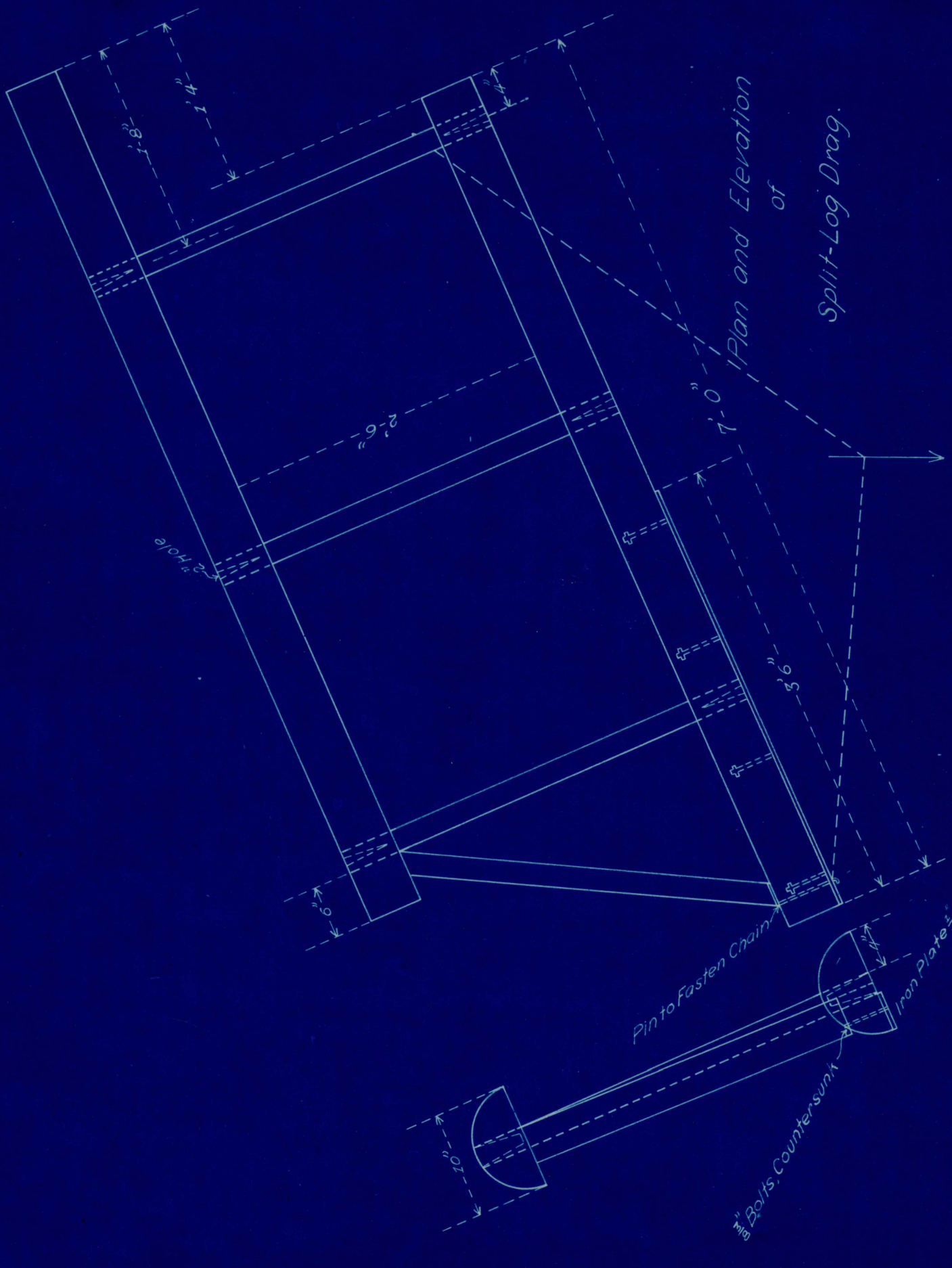
would accomplish the desired result.

It is a happy coincidence that in most of these districts where this kind of clay is abundant wood is also plentiful, thus affording an abundance of fuel. Of course work should be done in the dry season of the year. Good, sound wood, as dry and well seasoned as possible should be obtained and stacked at convenient intervals along the road. After grading the road to an even width between ditches, it is plowed up and furrows made crossways of the road. These furrows should be two feet longer on each side of the road than the wood. Then across these furrows the first course of wood is laid longitudinally to form flues. Now another layer of wood is thrown irregularly across this and in spaces between these logs loose clay is piled, care being taken to have the lumps of such size that a draft will be formed easily. Then another layer of wood is laid on and the cracks filled with small combustible material after which the top layer of clay is put on. Now the whole pile is surrounded by large lumps of clay from the road bed and the whole tamped off so as to hold the heat as long as possible within the mass! About fifteen or twenty flues can be prepared for firing at once. If the firing is successful the material will be entirely changed in character and will have no tendency to cake or stick. The covering for the road bed is now ready and ir should be brought to a high crown before rolling in order to allow for the compacting of the material. By this method the cost of transportation of the clay is avoided and the subgrade of the roadbed is burned as well as the covering. The method id a good one and is economical in irs first cost, the cost of a mile of such construction being about fifteen hundred dollars.

THE USE OF THE SPLIT-LOG DRAG ON EARTH ROADS.

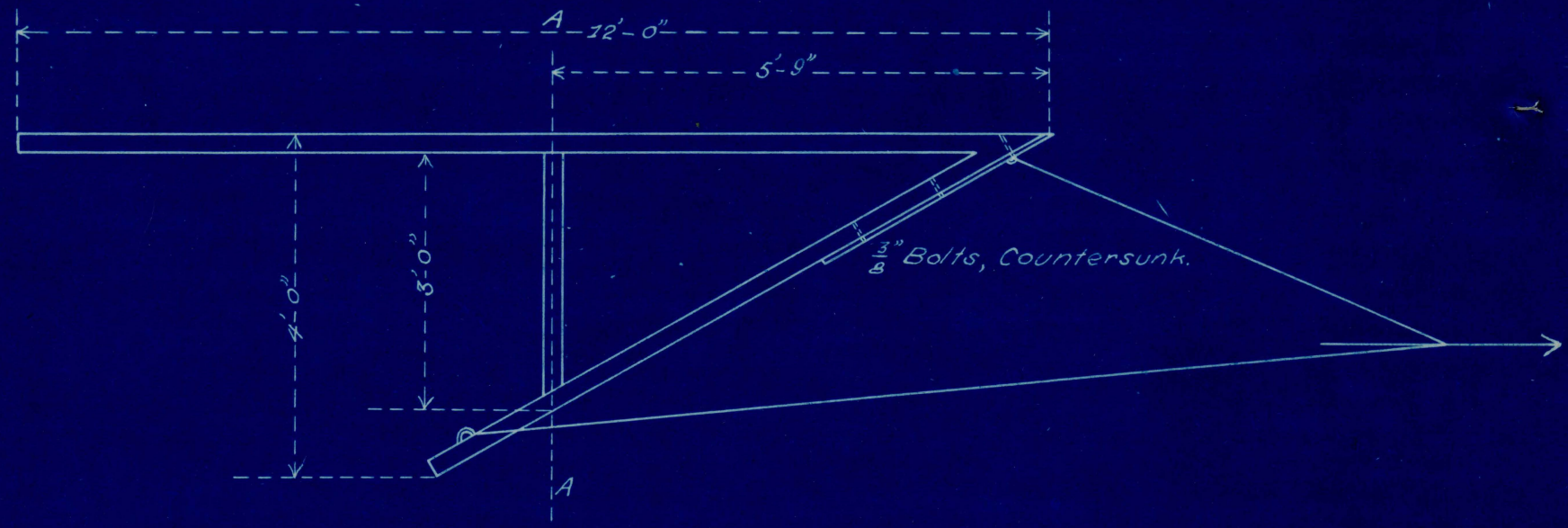
Possibly more than any other form of Roads, Earth Roads are in existence at the present time and will continue to be used by our rural inhabitants for a long time to come. Therefore it is expedient that some device or method be found which will improve and keep these roads in good condition at as small a cost as possible. Many different methods have been discussed at length, but one seems to have gained a better hold on the people than the rest. This is the Split-Log Drag. A brief description of its construction and use is therefore in place at this time. The best form has proven to be the two-slab variety, in which there is a liberal "set-back". It should not be made too heavy, in fact one man should be able ti lift and handle it easily, for as a general thing one man is expected to operate it, and for this reason the double form has been discarded and only one side of a road id dragged at a time. The timbers should not be square but sharp edged slabs are best as will readily be seen later. A good drag should be seven or eight feet long and the two slabs about thirty inches apart. A platform of inch boards should be placed between them for the operator to stand on. Drags are sometimes constructed of planks instead of logs, but the same general plan is followed.

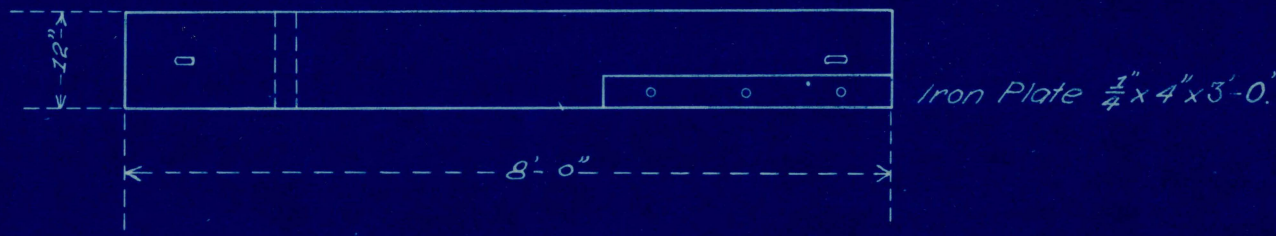
How To Use A Drag: The successful operation of a drag involved two cardinal principles: First, the length of the hitch, and second, the position of the driver on the drag. Each is very important and the successful manipulation of a drag is dependent upon them. The length of the hitch from the blade end should be such that the drag will follow the team at about forty-five degrees. This will cause the dirt to move along the blade easily and give comparatively light draft to the team. The distance of hitch also affects the depth of cutting, a long hitch causing the blade to cut deep, and a short one


Plan and Elevation of Split-Log Drag.
7'-0"
3'6"
2'-6"
1'-8"
1'-4"
Pin to Fasten Chain
Iron Plate
Bolts, Countersunk

lifting the blade so that it only shaves off the top over which it passes. Having attained the proper hitch, the cutting of the blade may be made heavy or light by the driver shifting his weight from front to back. The drag should be driven with one horse on one side of a wheel rut and the other on the other side and the return trip should be made in the same manner on the other side of the road, thus the loose earth scraped off is forced to the center of the road and the drainage conditions improved. The drag does best work when the roadway is moist but not sticky. Sometimes when the road is very rough and full of holes and ruts the drag may be used to advantage when the ground is slushy thus getting all the holes filled which might not be done if the ground had more body. If this be done just before a cold spell and the roadway be allowed to freeze smooth once a very lasting effect is obtained. If a smooth surface secured by this method be compacted and rolled in this condition it becomes extremely hard and resistant to traffic. One of the valuable results of dragging is the reduction of dust, for the particles of clay cohere so strongly that there is but little wear when the surface is smooth. In soils full of loose stones and even some larger surface rocks the drag has done a very effective service. The loose stones are placed in a heap in the center of the roadway and the loose earth is thrown around the surface rocks so that the result is a smooth roadway. The loose rocks can then be removed from the center of the roadway whenever desired. The cost of maintaining a road by the use of the split-log drag is variable and no accurate estimates or figures are available, but the average cost of maintaining country roads in several counties without a drag was about $42 a mile a year and it is safe to say that with the drag it would be materially less.

To summarize:- The advantages to be gained fron a split log drag are





Plan of Plank Ditch Cleaner

as follows:-

1. The maintainence of a smooth, serviceable road, free from ruts and mud-holes.

2. Obtaining such a road surface with the expenditure of very little money as compared with other roads.

3. The reduction of mud in wet weather and dust in dry weather.

The Ditch Cleaner: This device, designed to clean ditches, is made of a guide plank and a mold board. These are braced at an angle of about thirty degrees by a cross piece as shown in figure . The cross brace is hollowed some on both sides in order to prevent earth from heaping up in front of the brace. A light platform is needed to make the use of the ditcher safe. The hitch is made nearly parallel to the back board and two or three horses are used according to the local situation. A weight of about two hundred pounds is needed and should be placed over the front end. The object to be diligently sought is a smooth even ditchway, thus giving no obstruction to the free flow of water. This condition can be obtained very readily by an experienced driver, who by shifting his weight forward drives the blade into the ground and if he moves back the pressure on the blade is relieved and the pull on the chain tends to raise the blade. This instrument is also helpful in maintaining a slppe from the center of the road to the ditch allowin the rainwater to collect in the ditches and not on the road bed as is so often the case.

MACADAM ROADS.

The treatment of macadam roads here attempted does not claim to be exhaustive or very extensive, but the main essentials will be taken up as

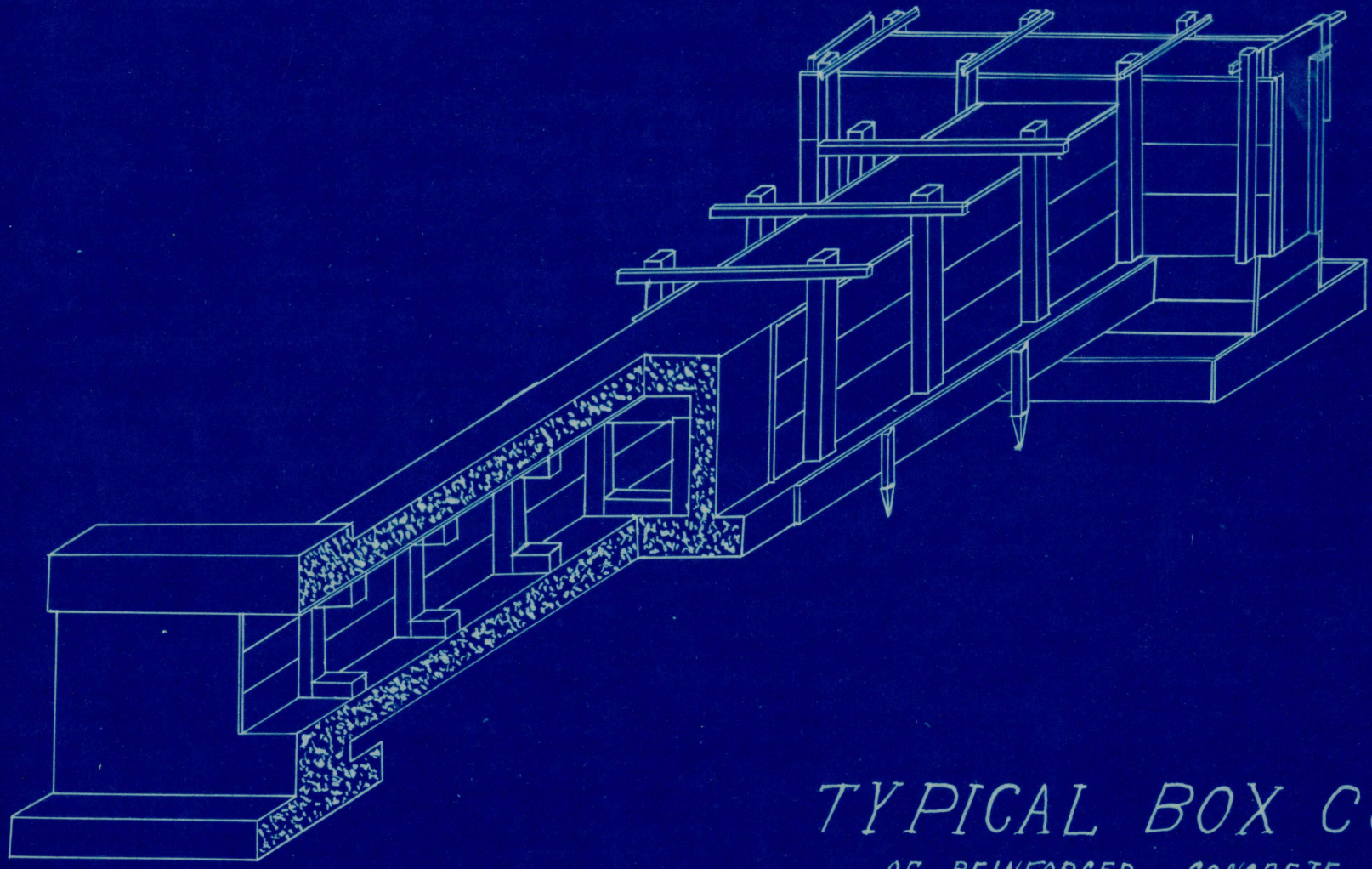
they seem to be important in the proper consideration of the subject. The word macadam as here used refers more particularly to the type of road now composed of broken stone of varying size suitably bound together into a compact mass so as to be substantially a sort of concrete, but with no binding material other than the dust or stone screenings obtained by the crushing of the rock. The macadam type of roadway is particularly well adapted to main highways connecting centers of population on which travel is more or less frequent. It is not an economical form of pavement for the streets of large towns or c cities and is too expensive to be built in rural districts to any great extent.

Varying with local conditions of travel , it might be stated that for ordinary country roads a broken stone surface of from twelve to fifteen feet is sufficient, as two vehicles can pass comfortably on such a width. The edge or shoulder of the macadam should be made firm enough for the occasional passage of wagon wheels over them . The depth of the broken stone is at this time made as thin as possible to obtain a good hard surface, as the material to be used as the foundation is usually much less expensive than the broken stone. An ordinary macadam road is, as stated above, usually from twelve to sixteen feet wide with shoulders from three to five feet wide on each side. The depth of broken stone may vary but usually from six inches at the center to four inches at the side should be the slope given to it.

Taking up the nature of the stones which are best for use as macadam road surfaces, we recognize that the principal qualities to be sought are hardness and toughness. The cementing quality should be borne in mind also. Usually, though, the choice of rock for this purpose is limited, as a section of a country about to build such a roadway would be inclined to use the material directly available in that section. Trap rock,- a certain form of igneous rock, has long been considered the best material for road surfacing.

The time of breaking the rocks for road surfacing by hand has passed and now the contractor for such construction is expected to have his machinery for doing this work. A machine for this work can be had at varying prices and usually in country districts a portable outfit is bought. This consists of a crusher, a sifter, and an engine for operating and moving the outfit. The machine is set as nearly as possible to the place of construction and the rocks hauled to the road from it. This crusher is a large machine consisting of two parts, the first being the crusher proper, and it is connected to the other by a chain conveyor which carries the broken stone and dumps it into the cylindrical sifter of the other receiver. This sifter has three sized of holes , one two and one half inches, another one and one-quarter inches and the other allows rocks of less than one-half inch in diameter to pass through. Thus the different sizes of rocks are assorted automatically by the machinery. Another important implement is the steam roller. A ten-ton roller is usually sufficiently heavy for the construction of ordinary country roads and besides the country bridges and culverts are seldom strong enough to stand the weight of the larger rollers. The roller is used to compact the masses or layers of broken stone and give the surface a hard netallic covering. Watering carts are needed for several purposes, viz: to keep water in the bailers of the engine and roller, and also to sprinkle the road surface before rolling is begun.

Fixing the grade of a roadway is one of the most importand of the fundamental operations in the construction. A macadam road should always have a slight incline to give the water some longitudinal tendency to run off, and the grade should be as slight as possible under local conditions in order to allow large loads to be taken over it with minimum effort. The engineer in



TYPICAL BOX CULVERT

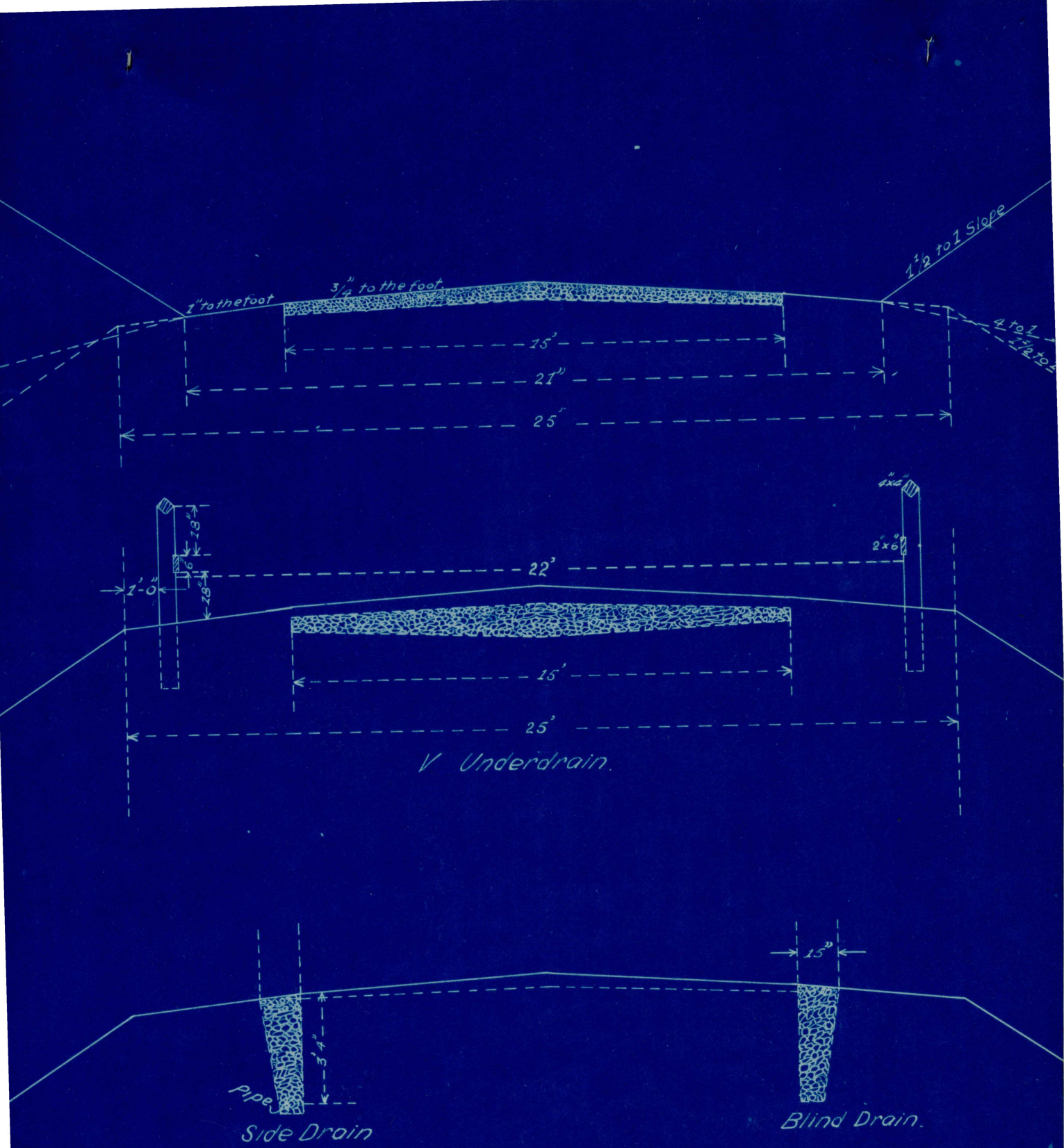
OF REINFORCED CONCRETE

SHOWING FORMS.

L. B. D. Del.

charge should also try to so fix the grade that the cuts will just about furnish sufficient material for the fills along the route, and thus the cost of hauling to or from in order to get a proper grade is to a large extent overcome. The road should be brought to a crown of some slight elevation and the gutters or side drains should be so fixed that the rain water would freely flow off and away from the road. This condition necessitates the introduction of culverts in many places and some forms of culverts are shown herewith.

Water should never be allowed to accumulate under a macadam road. It tends to soften the foundation so that heavy vehicles will make ruts in the surface and in freezing weather the surface rocks will "heave" and thus cause the larger ones to be forced up on top and in Spring the macadam will be found to be rough and weakened. In order to overcome the tendency of water to accumulate under a roadbed several kinds of drains are suggested and used. Side drains consist of narrow trenches filled with broken stone or gravel, or perhaps a pipe five or six inches in diameter is inserted among the stones at the bottom. This pipe is laid with open joints true to grade and is carried to a proper outlet. Sometimes in case the pipe is omitted the trench is filled with stones and this form is called a blind drain. Another method of carrying off the water from under a macadam road is by means of a V-shaped drain. In this method the subgrade is excavated to comform to a certain extent to a V with the bottom at the center of the road. Naturally the V would be quite flattened out. The center should be fairly true to grade in order to secure the free flow of water. This excavation is filled with stones of varying size through which the water may flow to a suitable place of outlet by trencehs to the side. Such a drain can usually be constructed at less cost than two side drains. The removal of surface water has been discussed to some extent above.



Typical Cross Sections of Macadam Roads.

The proper careofthe shaping of the subgrade is responsible to a great extent for the future good condition of the road. The subgrade should be carefully graded and crowned and the bed rolled well with the roller before any stone is placed upon it. If the macadam is to be thicker at the middle than at the sides, a part of the crown should be built in the subgrade. The road is now ready for the broken stone. As intimated above the crushers of modern times assort the rocks into three different sizes and these are used separately in building a road, in order to secure smoothness and even wearing. The large sized stones are put down first and rolled slightly and this is then covered with the medium sized stones. These two layers are rolled carefully and will usually compact to about fifty or sixty percent of their original thickness. The best method of rolling seems to be to begin at the edge of the roadway and gradually work toward the center, thus preserving the crown. When roadway has been so compacted that the stones are soild under foot and there is no wavy motion under the roller, this portion of the road is ready for the third and last layer of stone. This course is composed of the smallest pieces of stone which go through the screen on the crusher and is usually not made any thicker than about one inch. After this has been spread on the surface of the two bottom layers of stone the watering cart should be put on in advance of the roller and as much as possible of the dust and screenings should be flushed into the crevices between the stones. Then the mass should be rolled until the water puddles on the surface, at which time the voids can be safely assumed to be filled. The operator of the roller should be a skilled man in the handling of it as much depends upon the manner in which this work is done. The cost of macadam surfaces can hardly be given to any degree of accuracy in a general statement , but it can be seen from the various operations necessary and the machinery involved that the cost per mile is a

considerable item and a community should be careful in placing contracts or entering upon the work of building a macadam roadway.

The maintainence of a macadam road needs some discussion at this point. It is perhaps a little too strong to say that the maintainence of such a road should begin the day of its completion, but it is certainly safe to say that it should be the object of attention from that time forward. The road surface proper most likely not need any actual repair work for a year or two, but the sides must be constantly looked after in order to prevent undermining of the subgrade and consequent deterioration of the surface. In the course of time the macadam surface will become worn and need repair. No one can state accurately how much of the macadam surface will wear off in a given time. The length of life of a properly built macadam road depends upon the volume and kind of traffic over it, the quality of the stone of which it is composed, and also upon the climatic conditions of the locality. The old notion that a macadam road surface should be restored annually to its original thickness was doubtless an excellent precaution and preservative for the road, but it was very costly and could not be kept up any great length of time economically. The present practice is to keep the surface always smooth, to fill any holes or incipient ruts as they appear, but to do no actual resurfacing until the surface has worn down to the second course of stone. When the road has worn to this condition resurfacing should be at once begun and it can then be accomplished at a relatively small cost, as the foundations are intact and require no additional work and the new stones settle quickly into place and stay there. It is very rare that a macadam road properly built becomes muddy, except from mud tracked upon it from side roads built of earth. But it is a fact not to be disputed that they are often very dusty and disagreeable from this cause. The sprinkling cart cannot be kept in a community

and sent out on country roads at intervals, but as a matter of fact water, when properly applied, not only lessens the dust but preserves the road as well. We shall have something further to say on the subject of dust and dust-preventives later. A macadam road such as is outlined in this paper will be more expensive to maintain than either of the other two kinds outlined before it, but such a road is much more satisfactory for all kinds of travel and can be kept smooth and hard and serviceable at all times of the year, and it is evident that these conditions cannot be met by either of the other kinds mentioned above.

AUTOMOBILES- THEIR EFFECT.

AS intimated in the first part of this paper, a discussion of the relation of automobiles to good roads will be attempted here to a certain extent. The motor car has gotten to be a reality and every roads in the country is subjected to some extent to the use of automobiles, whose occupants are travelling either for pleasure or for business. The nature of the effect of this travel is to be investigated and remedies given which will overcome the bad or injurious effect of these motor cars. These cars are possibly the worst foe of the macadam road at the present time, and wherever it is possible motorists use macadam roads. The steel wheels of the ordinary wagon grind off sufficient powder to serve as a binder, replacing the binding material washed off or blown away by winds. But the swiftly moving, pneumatic-tired motor car of the present day presents an entirely new problem to the engineers of highway construction. These cars are very heavy usually and their wieght compresses the pneumatic tire to a wide flattened surface, and this weight, together with the swift motion of the car tend to produce a vacuum just under each wheel as it moves forward. The loose dust and small stones are

thus drawn out of the crevices and into this vacuum and the wind catches the dust and carries it off. The ultimate effect of this kind of travel is obvious. The dust is blown away and the rubber tires of the car do not tend to produce any more. As a result the binder of the stones is lost or blown away and intime the loose stones will work up on the surface forming a roggh and uneven roadway. Anoter effect is that rainwater will finds its way easily into the roadbed through these crevices, and this is finally disastrous to a macadam road as suggested above. Another phase of the subject and one which is probably as important as the proper care of the roadway itself, is that the fast moving motor cars cause the dust to be raised into the air and carried over adjacent territory. It is a well known fact that dust is a spreader of many injurious diseases, and along a much travelled road this problem may become so great as to affect the value of real estate to a great extent. It is thus a matter to be studied and overcome as rapidly as possible from every standpoint. This discussion may appear to be a rather severe arraignment of motor car traffic, but it should not be forgotten that there is another phase of the subject worthy of serious thought. The automobile, while tending to destroy macadam road surfaces, has been an important influence, not only in the building of many miles of well constructed highways, but also in making urgent the study of road preservatives. The dust nuisance existed before the advent of the motor car, and if its coming serves to bring about a really beneficial effect in overcoming it, the travellers of highways will have cause to be thankful for its detrimental effect at first. Many methods and remedies have been suggested and tried, but no very successful one has bee n found up to the present time. It is obvious that the problem can be solved only by the adoption of one or two general methods: (1) By constructing roads in such a manner as to reduce to a minimum the formation of dust; and (2) by treating

the surfaces of existing roads with materials that will give the same result. The subject of dust preventives will logically follow here and it is brought in at this point.

DUST PREVENTIVES.

As intimated above that caused for work along the line of dust preventives are two: the suppresion of disease along the highway, and the injurious effect on the roadway of the dust being blown away. Both of these are very important and consequently there has been a great deal of study along the line of dust prevention. The work has not progressed to such a stage at this time that particular methods and materials can be cited as the best method of overcoming these difficulties, but the work already done has given those who have studied it a great deal of satisfaction. In many treatments of this subject, the various dust preventives are classified under many heads, but two general heads will be sufficient for those treated here, viz: (1) those applied in their original condition and (2) those applied in emulsion or solution through the agency of water. Another classification and one not at variance with that above is: temporary binders, and permanent binders. It is easily recognized that the essential feature of any dust preventive is its binding power, or in other words its power to hold together the fine material produced on the surface of the road. It is obvious that in order to keep down the dust on a roadway the temporary binders will have to be applied with more or less frequency, according as their properries approach those of the permanent binders. It is not to be understood by the word permanent, that a binder is meant which will last for years, but simply one which will last for a relatively long time, - for a season for instance.

Water, salt soluitions, certain light oils and tars, and oil and tar

emulsions constitute the first class, while the heavy oils, tars, semi-solid, and solid materials constitute the second class. Salt solutions are valuable to the extent that their salt is hygroscopic in character, and absorbs and holds water much longer than the ordinary dust of the roadway would hold the water if treated with water alone. The light oils and tars as well as the emulsions are dependent for their effect upon the retention by the road surface of a comparatively small amount of true binding base after the volatile products have evaporated. And finalliy when this binding base has evaporated or destroyed it becomes necessary to apply more material, and the residual of continued applications may finally harden the surface to some extent and prevent wear. In passing to the second class or heavy oils and tars we recognize that we have here practically the same chemical properties but to a more pronounced degree. Their permanent qualities consist in their relatively great amount of binding base, and hence their results are of a more lasting character from a single application and are productive of a better wearing surface and are hence factors in the lessening of the formation of dust to a considerable extent even after they themselves have become saturated with dust. It has been found that with few exceptions all of the true binders are bitumens, and they may be either natural or artificial.

A full discussion of the methods ofapplication and the properties of tras, oils, etc. could not be attempted in a paper of this nature but it will be necessary , in order to become familiar with the use of them in connection with dust prevention on public roads, to outline briefly some of the ways thay are obtained and give some of their properties. Crude tars, as well as specially perpared tars and tar emulsions,have been much used for dust prevention ever since the subject was first seriously considered. As a class, tars are liquid bodies obtained from the destructive distillation of such materials as coal, bone and wood. They are of a very complex nature, containing various chemical

substances in varying amounts. Coal is by far t e most important source of tar at present and the method of obtaining tar from it will be first noticed. The oldest form of coke oven, and one which is extensively used in this country, is known as the "bee-hive", and in this form no tar or other by-products are saved as they escape through the flues as gas. Other forms are slowly replacing this one now and in a short time the output of tar will be materially increased. The method of recovering the tar is as follows:- The coal is charged into long narrow chambers of about five tons' capacity and is heated by flues in the walls. The volatile matter passes out through the top and is conducted through a series of washers and scrubbers as in the manufacture of gas in order to remove the tar and ammonia. Low temperatures are maintained for a reason which will be taken up later. The tar is then collected and used in accordance with approved methods.

In the manufacture of illuminating gas bituminous coal is the great factor. The tar, which is a very large by-product is collected in the hydraulic main, condensers, and tar towers, and is allowed to settle for some time to free it from other by-products. The crude coal-tar which remains is a black viscid fluid of peculiar odor. The nature of the tar varies with the nature of the coal from which it is derived and the conditions under which it is produced. The temperature at which a tar is produced is a very potent factor in determining it value as a road builder, for at a very high temperature the gaseous hydro-carbons are apt to be dissociated and free hydrogen gas given off and the carbon deposited in the tars. As the value of coal tar as a dust preventive lies mainly in the binding power of the heavy bitumens contained in it, it is quite evident that an excess of carbon or other material in will prove detrimental. It may be recalled here that this is the reason for the low temperature advocated for the coke oven production of tars. Various methods of refining this crude tar have been employed and the thick, viscuous material known as

pitch,which is left represents the true binding base of the tar if it was originally produced at a comparatively low temperature. In preparing a tar for use as a dust preventive most of the valuable products are removed by various methods and the least valuable are run back into the pitch until about the same consistency is obtained as that posessed by a heavy crude tar. Water gas tar is used to a slight extent as a road builder but it does not compare favorably with some of the lighten oils and hence will be passed over with little comment.

Ih the application of the tars to the road two general methods are employed: one by applying the tar to the surface of the road, and the other by constructing the road of tar-covered material. The first method is considered under two heads. First by applying the tar to the finished road, and next by applying it during construction. Most coal tars are very viscuous and could not be applied at all satisfactorily while cold, and consequently heat is usually used to make them liquid. The road surface should be free from dust, dry and warm if possible, and by all means smooth and free from ruts and hollows. After sweeping the loose dust and particles off the surface, the hot tar is spread on and thoroughly broomed in, and the road closed to traffic until the tar dries and hardens, and then a small covering of sand or gravel is applied to absorb the extra tar. Mechanical means of applying the tar have been invented and are proving economical and good results are being obtained with them.

In constructing a new road, other methods of applying the tar are used. The bed should be shaped and consolidated and the first course of stone applied and rolled. Then sometimes hot tar is applied to the courses singly but this is not at all necessary and an application to the top layer may be sufficient. After this is put on a dressing of fine material is applied and the whole is well rolled. A road so treated will have all of it s interstices filled with

hard material and no excess of tar is used. A road so constructed will approach very closely a road built of material which has been tarred previously. A properly tarred road after being subjected to travle for a short time closely resembles asphalt. It is smooth anf firm, not so hard a surface as asphalt, and is practically noiseless. While in good condition it is to a great extent water-proof and almost dustless, and if the proper amount of tar has been applied it offers less resistance to traction than an ordinary macadam road. The proper amount of tar required will depend on the fluidity of the material and the absorbing power of the roadway. The cost of tar treatment on a road cannot be definitely stated at this time, but recent reports of the Massachusetts Highway Commission seem to show that a coating of tar suitable for most roads will cost between six and ten cents per square yard of surface, and the maintainence cost is reduced materially.

There are various kinds of oils derived from innumerable sources, the most general classes being animal, vegetable and mineral. Of these, mineral oil is the only one of sufficient value to be considered as a dust preventive. Here as in the case of tars, the value of an oil for this purpose lies in the amount and quality of high-binding bituminous base retained by the road surface after evaporation of the more volatile constituents. The oils from the wells in the eastern part of the United States are for the most part paraffin oils and are practically useless as base binders in dust prevention. The western oils are of asphaltic character and are very valuable as binders, while the wells of the south are mixed and only of relative value. Various methods of refining the crude oils are used and the residuums from these refinings are what is of value in road building. In applying heavy oils to a macadam surface the same general methods are followed as for the application of tars. The surface should be smoothed and all foreign matter removed, and then the oil may be applied

either hot or cold according to its viscosity and penetrating ability. Applying oil cold is to be preferred on account of its economical cost, but some heavy oils will have to be heated in order to be properly applied. Patented devices have been employed and can be attached to most any form of tank wagon, and if the oil is fluid enough such devices will do away with the necessity of brooming, which is done when the oil is applied cold or by streams from pipes. After such application is made to the surface a coating of sand or stone screenings is applied and the whole rolled until it is well compacted. As in the case of tars the main object is to obtain an even coating and to have it well absorbed by the road surface. In some cases when the oil is very evenly distributed and absorbed it is found to be unnecessary to use the roller as the ordinary traffic will serve the purpose instead. Oils are sometimes applies during the construction of macadam roads and the method followed is very similar to that of applying tar to such roads during construction. Oils have been used in some sections on earth roads with varying success, according to the locality and the kinds of oils used. It has proved to be a very effective dust layer and in some cases has improved the condition of the road to a considerable extent.

Water and salt solutions are,as mentioned before, temporary binders and have to be applied at more or less frequent intervals in order to suppress dust. Owing to this quality of the binders of this class, it is evident that the frequent applications will be more or less expensive, and that inasmuch as very little permanent benefit is attained this method is not economical. When salt solutions are used the effect is somewhat more permanent than with water alone, as it is well known that salt has great affinity for water and will absorb dampness from the atmosphere. This quality is depended on to a certain extent when salt solutions are applied, and the result is a somewhat more lasting effect and the number of applications is therefore reduced. The "bittern" or

mother liquor which is run off in the manufacture of common salt from sea-water is perhaps the best salt solution obtainable for road use. It contains very little of sodium chloride and is less injurious to the feet of horses and the varnish of carriages than most of the other salt solutions that have been used. Its use for this purpose, however, is covered by patent. Calcium chloride has been used to a slight extent for the purpose of dust prevention, and when properly applied has proven successful. In most cases it is first applied on the unprepared road, being sprinkled usually from an ordinary watering cart. About two applications of 20% solution are made in the first week or ten days and the salt thus applied has a tendency to retain moisture to a considerable length of time. In the course of time rains wash the calcium chloride out of the roadway and the applications made from time to time are usually from 8% to 10% solutions. Its principal advantages are that it is odorless and clean. The use of it tends to prolong the life of the road by retaining the products of wear. There are a number of other salts or salt solutions which are used in dust prevention but the treatment of them must be omitted inasmuch as they are all of a class and several types have been discussed.

The temporary oil and tar binders, emulsions and similar preparations come next in order and a short treatment of them is necessary. Some of these are applied as they are found in nature, while others are prepared and applied as emulsions . Vegetable oils, petroleum and tar oils are of the first kind. These materials all contain a certain amount of true binding base, and although to a very limited extent result somewhat in the accumulation of this binding material after a season of application . Their effect, however, is not considered to be of very material value. Water-gas tar is one of the best temporary binders which can be applied in its natural state. It is readily absorbed by the road and contains a sufficient amount of pitch to reduce dust formation to

a considerable extent. The form of application for the materials of this class is similar to that for calcium chloride treated just above.

Emulsions may be obtained either by chemical or mechanical mixing. Perhaps chemical emulsions have been most used for dust preventives up to the present. They are oily substances, the manufacture of which is usually covered by patent. Waste products from various arts can frequently be utilized in their manufacture and tend to cheapen the material . The general method of making these substances is to take some oily material and add to it a certain amount of alkali materail, which makes it miscible with water. A mechanical mixer has been used to some extent in which there are two tanks which feed into a common receiver, in which there are a number of revolving discs or blades, which thoroughly mix the water from the one tank with the oily substances from the other. This then feeds the material to a sprayer which applies the emulsion to the roadway. The water eventually evaporates and leaves the binding materail to get in its work as a preventive.

In the choice of dust preventives economy is usually the paramount consideration. And in the country there are two classes of roads to be taken into account- the hard and soft, or the macadam and other broken stone roads, and the dirt roads. For the hard roads oils and tars are recognized to be best suited to the needs of rural communities , and for dirt roads oily substances have proven most successful and economical as dust preventives with any permanent value. The choice between oil and tar will depend on various considerations of locality, climate, rainfall and so forth, and a definite statement could not be given here. For dirt roads an oil containing the maximum amount of base-forming materail would of course be selected. A very clayey soil would be treated with a moderate amount of sand before applying oils as said before. In suburban roads a wider choice is had as all kinds of material are easily ob-

tained and usually water pipes are at frequent intervals and salt solutions can be frequently applied. On roads where heavy traffic is sustained the heaviest and most permanent binders should be used by all means as this will undoubtedly prove the most economical in the end.

On the whole the selection of the material to be used as a dust preventive is a rather difficult proposition and has been given quite a good deal of study by experienced road builders and experimenters in road building. A much more extensive treatment of the subject than that given here has been made by the Office of Public Roads and the results of their experiments can be found in bulletins published by that office.

GOVERNMENT CO-OPERATION.

Years ago when the civilization of our country was less advanced and the country less thickly populated, the need for good roads was considerably less keenly felt than at the present time. The local supervisor of road building was also equal to the occasion so long as his duties were simply to assist nature or remove obstructions along a proposed route, but at the present time in consideration of the more thickly populated sections a better roadway is needed and a hard surface is required. The local supervisor now feels his deficiency in skill and resources and he finds that, contrary to f rmer times, he cannot call upon peolpe to give a certain number of days for improving the public highway. In order that funds may be available now for road construction most states have passed laws levying a direct road tax on not only inhabitants of country districts but also on city people. This puts the road commisioners in a position to hire both skilled and common labor to build the proper road for each locality according to conditions. Many states have also passed a law allowing each county to call upon the convicts of the state penitentiary for

road work, thus deriving some real benefit from these people who have previously been an expense to the state. The National Government has established an Office of Public Roads in the Department of Agriculture and experiments are being made from time to time and the results published and distributed from time to time to local road builders. Thus there is only one initial cost in ascertaining these facts and all the states may abide by such knowledge. The Government will also enter into an egreement to build object lesson roads as they have done on several occasions, in which they furnish expert labor and engineers for no compensation , while local builders furnish common labor and machinery. This method is very advantageous in that the local officers may have a practical demonstration of the best method of improving the roads at that place and the expert advice is absolutely free. Many miles of Object Lesson Roads have already been built in different states and the Office in Washington is being more recognized each year by Congress and liberal appropriations are hoped for and expected from now on. It is hoped that each local board of supervisors will profit by the experience of the Office and that the roads which are to be built in the future will be built so that they will withstand the traffic to which they are to be subjected and that permanent good will result from the w work of the Office of Public Roads.