ENGINEERING AND COST DATA RELATIVE TO THE INSTALLATION OF STEAM DISTRIBUTING SYSTEMS IN A LARGE CITY

THESIS FOR DEGREE OF M. E.

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1916

Steam-pipes
Pipe-fittings

Mechanical engineering

T H E S I S

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INSTALLATION OF STEAM DISTRIBUTING SYSTEMS

IN A LARGE CITY.

BY

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JUNE

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THESIS

Thesis.

Object.

The proposed object in writing this thesis is to give data and information which,it is hoped,will be of aid to the Engineer who is about to design a distributing system of steam mains,to discuss specifications for these in a general way,and in some instances to outline the manner in which to pursue the work.

Introduction.

Between the corporation desiring the work done and the forman who performs it stands the Engineer who has designed and who usually superintends it's execution. He is in the employ of the persons promoting the enterprise, and it devolves upon him to make sure that those who retain him receive an honest and fair return for their money. The Engineer must bear in mind at all times that he is not to be an enemy to the foreman,but that he should work in harmony with him,and should do all he can to further the rapid and harmonious completion of the work,being careful,of course, to see that nothing is done which will in any way result in an inferior construction. As the Engineer's decisions are final it behooves him to be careful that no injustice is done to any one.

Some of the first questions to be decided in the construction of a pipe line are it's location,cost,and revenue. Location depends upon several factors,the most important of which is the ease with which the transmitting unit or pipe line may be installed from the generating source or power house to the locations of the demand or customers.

In arriving at the relative cost of installation the factors of labor,material,paving inspection and maintainence have to be reckoned. The revenue depends upon the number of customers that can be taken on and the saving obtained by cutting down theline loss in the mains themselves.

Generally speaking the construction of underground steam mains per foot is more expensive than the construction of any other underground installation. However any operation which involves the disturbing of the street surface and calls for underground construction brings with it,in addition to the usual engineering problems,a multitude of incidental ones which must be handled and solved by the Engineer as a part of the whole engineering work under his charge.

Investigation.

The character of the soil underlying the site for the pipe line should be carefully examined in order that the foundation can be so planned as to keep the load imposed by the pipe and fittings within the safe limit. For ordinary pipe lines up to and including twenty inch es in size, under ordinary soil conditions no special attention as to foundation is required,however the writer strongly recomends that test holes be dug at numerous points along the site of the line and the character of the soil and undersurface conditions determined. As the progress of the work increases more care should be taken.

With the ordinary pedestrian and vehicular traffic existing in a large city any constriction of the roadway by excavations in the street creates a problem of utmost importance and allied therewith is the problem of arranging and carrying on the work so as to reduce,to a minimum, interference with normal business along the street. No less important is the safeguarding of the public against accident.

The principal problem of constructing a steam line lies not above but below the surface. Here you will meet with a crowded alignment of sewers,water mains,gas mains, duct banks and distributer conduits for telephone, telegraph, and electric power service.

Investigation of sub-surface conditions in advance of construction work can only be complete enough to determine in a general way the alignment for the steam pipe. This alignment of the new mains can only be determined from an examination of tests pits dug as the work progresses, together with such information as can be obtained from complete or incomplete records of the various public service corporations and from surface indications of existing sub-surface structures. Some special investigations should however be made in advance of the work. These should cover points known to be exceptionally difficult and complicated, such as street intersections along the route.

Drawings.

In order that the foreman may understand the scope of the work to be performed and the details of it's constructions, complete and accurate plans defining the methods of construction, material,etc.,to be used are a necessity. It is well to make assembled drawings showing the street and it's contents in plan and as many elevations as may be necessary to make the arrangement perfectly clear. Assembled drawings insure all parts of the line fitting to-gether properly and prevent mistakes such as attempting to run steam pipes where water pipes exist and so on. If assembled drawings are to be made the scale assumed should be sufficiently large to show the various underground systems and their relative locations. Twenty feet to one inch is about as small as can well be used. Elevations and special details should be drawn to a scale not less than $\frac{1}{4}$inch to the foot. All proposed locations of man holes and details of trap connections in the same should be detailed at the larger scale.

Size of Mains.

Having determined the location for the steam distributing main the next step would naturally be to determine what size of pipes to use and in determining the size of main or system of mains, the following brief method is meant to be suggestive only and the discussions of the various points are omitted. First the territory to be heated should be canvased carefully determining in as accurate a manner as possible the size of the present buildings in cubic contents of space, the possible life of these existing buildings and the possible future increase that might be expected for the next ten to fifteen years. The analysis of these results will give a fair approximation of the maximum load or demand that will be required at any one time on the lines. Allow approximately 100 to 150 cubic feet of space per square foot of direct radiation. This will depend entirely upon the type of buildings, office buildings requiring more radiation per cubic foot of contents than commercial buildings.

The next important step is to plot out the district in question into sections say by streets showing the maximum amount of radiation in demand along each section. Designate if you please these sections as Section A,B,C,etc., from this diagram proceed to determine the size of main to provide for any one section or group of sections keeping in mind any possible extensions to any one section. These sizes can be readily determined from the following formulae known as D'Arcy's formulae for flow of steam in pipes, namely

$$d = \sqrt[5]{\frac{W^3 L}{Cw(P-P')}}$$

where

d- diameter of the pipe in inches

W- Pounds of steam per minute

w- Weight per cubic foot of steam at line pressure

(P-P')- drop in pressure

L- Length of main in feet

C- Constant depending on size of pipe and can be assumed as follows:

20" - 62.9	12" - 62.1
18" - 62.7	10" - 61.8
16" - 62.6	9" - 61.2
14" - 62.3	8" - 60.7

The writer would revise the formulae to read thus:-

$W= C\sqrt{\frac{w(P-P')d^5}{L}}$, then assume a size of pipe and balance the equation. After a little experience the Engineer should find it easy to estimate very closely the required size without much cut and trying.

Allow 3/10 of a pound of steam for each square foot of radiation per hour, which willbe suffieient to supply the radiation and line losses. It is well to assume an average initial steam pressure in the lines of about3 to 5 pounds gauge, and a drop in pressure not exceeding 1 ounce per each 100 feet of run. Following out the same reasoning for all sections of the district will give the requires size of mains to be installed.

The next important step is to so lay out the material over this system of mains so that the maximum number of customers can be taken from the minimum number of fittings or outlets,care being taken of course to so locate each fitting with reference to the building lines that the shortest possible lateral may be run from the main to the point of supply for the customer.

Materials.

The quality of the materials and the installation of the same,as regards insulation,expansion,contraction and durability are the points of importance.

It is not the purpose of the writer to discuss the merits of the various insulators and fittings but rather to bring out the general practice that has come under his experience.

The best quality of strictly wrought iron line pipe must be secured,pipe being fitted with what is known as the long pattern line pipe couplings at all points except where fittings are placed.

A very important consideration in laying out a system of distributing pipes is the means to be provided for taking ca re of the expansion of the pipes when heated. Wrought iron pipes, where placed in the ground cold and put under low steam pressure,will,as we know,expand or increase in length. Devices must therefore be installed for taking care of these repeated elongations and contractions of the pipe as the steam is turned on and off the system from season to season. As far as possible these devices should be of a nature which will not require either frequent attention or expense, or make necessary the placing of man holes at frequent intervals.

Very ingenious devices known as variators are used for taking care of this expansion and contraction of the pipe. These expansion devices should be placed approximately 100 feet apart with an anchorage fitting, for holding the stationary end of the pipe, placed midway between. These anchorage fittings can either be an ingenious device known as an anchor special or a cross or tee. In case the latter is chosen, the writer would recommend using a cross or tee with a cast anchor base which can be securely anchored in a bed of concrete. Flanged cross fittings should be placed at the intersections of all streets, with valves on all sides, so that extensions to the system may be made or repaired without effecting the operation of any other part of the system. The writer has discovered that the initial cost of the extra valve, which may not seem necessary at first thought, is more than offset by the inconvenience that arises when future additions or repairs are made to any one section radiating from that point.

Various other fittings such as angle joints, wedges, tees, etc., are to be figured in the estimate of material for a line, but as these are depending upon local conditions the writer does not deem it necessary to deal with them at this time. All line material referred to in this thesis is equal in every respect to that manufactured by the American District Steam Company.

Insulating Steam Mains.

One of the first questions which presents itself in the problem of extended distribution of steam underground,is the proper protection of the distributing pipes and accessories against the loss of heat and the consequent condensation of steam.

In installing conduits for steam pipes the selection should be made after determining it's efficiency as a heat insulator,it's initial cost and it's durability. No material is an absolute non-conductor,some however obstruct heat passage more than others, For instance, the heat conductivity of heavy dense substances is very high. The conductivity of lighter materials is less.

But there are a number of other requirements which must be met before any material can be considered a satisfactory heat insulating medium. It should be,so far as possible, proof against moisture and steam. If not, the first time the line itself springs a leak or any seepage water enters, the insulation will either be ruined entirely or will be subject to rapid deterioration. It must be able to withstand the temperatures to which it will be exposed, without effecting it's physical structure. It must have a certain amount of structural strength and flexibility so that it can be applied without undue breakage and withstand vibration and ordinary wear and tear. It must protect the pipes against electrolysis which is a very important factor in large cities.

Moreover, that whatever material is used it should be easy to apply and easy to get at, as that reduces the cost of installation and maintenance. It must also be reasonable in cost taking into consideration not only first cost but the cost in the long run.

The writer's practice, ~~and one~~ which has met all the factors just cited to a resonable degree of satisfaction, is to cover the wrought iron pipe with three thickness of asbestos paper, bound on with ~~with~~ copper wire and then inclosed in a round, tin lined, wood casing having a shell four inches thick and with a dead air space of about one inch all around the pipe between the asbestos covering and the tin lining of the casing, the pipe being centered and supported by rollers spaced approximately seven feet apart.

As it is necessary to have certain fixed and anchor points in the line, and as all customer's service connections are taken off from these points it becomes necessary at intervals to break into the regular run of pipe casing construction and to surround the various devices set at these points with a different construction. The writers practice was to incase these fittings in a brick box ~~of~~ 8 inch thick, extending well below and above the fitting in question, planked over on top with two inch planking and with at least a 4 inch concrete cover over the planking to keep out any water seepage. The writer follows two methods of insulating these fittings; One being to fill the box with dry shavings and the other to cover the fitting with one inch thick felt blocks covered with a half inch layer of Asbestos plastic cement and over this to apply a canvas jacket saturated with hot asphalt and finished with a water proof jacket of Johns-Manville Asbestos roofing.The latter method, although found to have a greater initial cost,has proved to be the more efficient. Service nipples,extending well outside of the box,were left on all openings from these fittings,so that in case of any future connection,for a customer,the box would not need to be disturbed.

Drainage.

The grading of the mains is one of the most essential features,and it becomes necessary many times to shift the location of other existing underground construction; in order to provide a space for the steam main,so as not to create a pocket in the grade. When,however,natural conditions or non- changeable obstructions cause low points in the mains, provision must be made at such low points for relieving the mains of any condensation water through a steam trap into a sewer. The steam trap must in all cases be fitted with a by-pass. This allows a removing without shutting down the main.

Again if the main is to be divided into sections by valves,as at a street intersection,provision should be made for draining each section,for the reason that some part may be shut off at times.

Beneath the entire line, except in sandy soil or soil containing large quantities of gravel, there should be placed a drain tile not less than three inches in diameter, which at convenient points should be connected into the City's sewerage system. This tile should be surrounded with broken stone.

Trenching.

The amount of trench to be opened at any one time is variable, depending on local conditions of the street and City permit regulations, but can be considered in usual practice to be from 100 to 300 feet, assuming one half of this length sheeted and ready for the pipe line. Inall trenches from five feet or more in depth use not less than two cheekings of size 6"x8" per side and sometimes it may be necessary to use more, depending upon the depth and character of the soil as well as the surrounding local conditions. Sheeting can be either of steel or hemlock planking and can be spaced according to the character of the soil; loose sandy soil requiring closer sheeting than heavier soils.

All ditch cheeking should be thoroughly braced to prevent cave-ins, accidents to the workmen or the progress of the work.

In trenching, only such width of excavation should be made as to allow for rapid installation of the pipe; the reason being that, with the usual depths required for steam pipes, every extra fraction of width causes the cost to rise rapidly and neccessitates more precaution in the superstructures.

When refilling the trench, very great care should be taken to tamp the earth to a solid state,give it a thorough puddling,and allow it ample time to settle before preparing for the repaving.

FIG.-I.

FIG.-I, shows the installation of a 20 inch steam main intersecting diagonally across a twin car track where it was impossible to delay car service. The same shows unusual precaution in bracing.

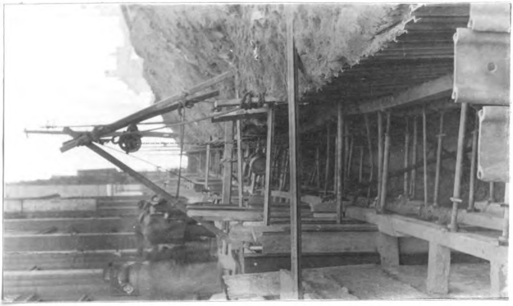

FIG.-2.

FIG.-2 shows the installation of a 20 inch steam main laid within ten feet of the retaining wall of a six story building. The average depth of the trench at this point is 10 feet and the soil is loose sand. Heavy bracing is necessary to prevent sliding.

Pavements.

Another principal factor, in actual street construction that must meet the Engineer's attention and be given very careful thought, is the tearing up of the pavements and the replacing of the same in good condition. In treating these factors it will be necessary for the writer to classify according to the kind of pavement. The reason for this is that the amount of pavement removed or relaid for a given size of pipe line is different for the different kinds of pavements. Tar filled pavements require a greater width than cement filled, and sand filled pavements more than tar filled. The amount of repaving in every case is found to be proportionate to the strength of the pavement in resisting the wear and tear along the edge of the openings that are made.

In removing the pavement only such width of the pavement should be removed as is necessary to allow room for the construction of the trench. These estimated widths are based upon the experience of the underground construction Engineer as to the amount of room needed and the corresponding width of the pavement to be taken up under usual construction conditions. These figures of course will vary according to the kind of pavement in question.

It should be the practice in construction work to mark on the surface of the street in advance of the trench gang, the width of the pavement that is to be taken up and the figures given later under this subject will correspond to the widths which should be laid out for the job.

The repaving over street openings is, in general, done by the Municipal Authorities. An exception may be made in the case of streets where the paving was put down by a Contractor under a guarantee for a definite number of years and in this case the repaving is done by the Contractor. In either case the cost is paid by the Company.

It is invariably found that the pavement is more or less disturbed along the edges of the trench as the work of constructing the trench proceeds. Some of the blocks of stone are loosened or pushed down and a certain amount looses it's solid foundation due to caving in of the earth along the excavation.

It is also necessary to tooth the pavement along the edge of the excavation by cutting out blocks or bricks so th at the repaving will be properly bonded to the old pavement.

Another factor that increases the amount of the repaving is the practice of including in the repaving any portions of the pavement adjacent to the excavation which are in poor condition or which show defects such as sholes or depressions. If the trench is near the curb or car tracks it is customary to repave all of the surface from the trench to the curb or car track.

For all of these reasons it invariably follows that on a job of any magnitude the amount of repaving is considerably in excess of the pavement which was taken up to perform the work. The amount of this excess varies,as noted before,according to the kind of pavement,being greater for less firm pavements. This has been carefully estimated by the writer from experience and is expressed as a per cent for each kind of paving as follows.

Kind of Pavement.	Per cent of Increase.
Medina Dressed Stone Tar Filled.	44
Medina Dressed Stone Cement Filled 6"Concrete Base	30
Medina Common Stone Tar Filled.	43
Medina Common Stone Sand Filled.	59
Brick Tar Filled.	52
Brick Cement Filled 6"Concrete Base.	39
Asphalt 6"Concrete Base.	36

The above figures show the percentage of increase of pavement relaid over that which had been removed for underground steam construction, representing 75 percent of the total repaving for three years.

Concrete Mat Under Paving.

A concrete mat six inches thick is in place under many kinds of pavements, and is usually found under such pavements as Asphalt, Cement filled dressed medina stone, Cement filled brick and all wood block. In the experience of the writer it was customary for the Company to replace this concrete with it's own labor force and for the city or contractor to relay the pavement on top of the mat.

Under the discussion of costs the repaving unit price does not include the cost of this concrete, therefore a separate price is estimated and must be applied to all repaving where the mat is found.

The estimated quantities of material for concrete as made of one part Portland Cement, three parts sand, and five parts crushed stone, laid down and tamped in place was as follows:

Material	Per Cubic Yard	Per Square Foot of Mat.
Cement	1.16 bbls.	.021 bbls.
Sand	.52 cu. yds.	.0096 cu.yds.
Stone	1.07 tons	.0198 tons.

Analysis of

Pavement Removed

for

Medina Dressed Stone Tar Filled Pavements

Medina Common Stone Tar Filled Pavements

Medina Common Stone Sand Filled Pavements

Brick Tar Filled Pavements

Size of main.	20"	18"	16"	12"	10"	9"	8"
Width of trench for pipe.	4'-5"	4'-3"	4'-1"	3'-7"	3'-5"	3'-4"	3'-3"
Width of pavement removed for trench*	6'-1"	5'-11"	5'-9"	5'-3"	5'-1"	5'-0"	4'-11"
Sq. ft. of pavement removed per lineal foot.	6.08	5.91	5.75	5.25	5.08	5.00	4.91
Opening in pavement for a Variator.	10'-0" x 5'-6"	9'-10" x 5'-1½"	9'-8" x 5'-0"	9'-4" x 4'-11"	9'-2" x 4'-10½"	9'-1½" x 4'-9½"	8'-11½ x 4'-8½"
Sq. ft. of pavement removed for a Variator.	55.0	49.9	48.3	45.9	44.7	43.5	42.2
Opening in pavement for Anchor Special.	8'-7½" x 4'-0"	8'-5" x 3'-10"	7'-10½" x 3'-8½"	7'-8" x 3'-6½"	7'-6" x 3'-5½"	7'-5" x 3'-5"	7'-4" x 3'-4½"
Sq. ft. of pavement removed for Anchor Special.	34.5	32.2	29.2	27.1	25.9	25.4	24.7
Opening in pavement for a Cross.	8'-6½" x 5'-6½"	8'-3½" x 5'-3½"	8'-0½" x 5'-0½"	7'-6½" x 4'-6½"	7'-4½" x 4'-4½"	7'-2½" x 4'-2½"	7'-0½" x 4'-0½"
Sq. ft. of pavement removed for Cross.	47.3	43.8	40.5	34.2	32.2	30.4	28.4

* Note:- 20 inches is added to the width of trench for loss in toothing the pavement along the edges of the excavation.

Analysis of

Pavement Removed

for

Medina Bressed Stone Cement Filled Pavements

Brick Cement Filled Pavements

Asphalt Pavements.

Size of main.	20"	18"	16"	12"	10"	9"	8"
Width of trench for pipe.	4'-5"	4'-3"	4'-1"	3'-7"	3'-5"	3'-4"	3'-3"
Width of pavement removed for trench.	4'-5"	4'-3"	4'-1"	3'-7"	3'-5"	3'-4"	3'-3"
Sq. ft. of pavement removed per lineal foot.	4.42	4.25	4.08	3.58	3.41	3.33	3.25
Opening in pavement for a Variator.	8'-4" x 5'-6"	8'-2" x 5'-1½"	8'-0" x 5'-0"	7'-8" x 4'-11"	7'-6" x 4'-10½"	7'-5½" x 4'-9½"	7'-3½" x 4'-8½"
Sq. ft. of pavement removed for a Variator.	45.8	41.9	40.0	37.7	36.5	35.7	34.3
Opening in pavement for Anchor Special.	6'-11½" x 4'-0"	6'-9" x 3'-10"	6'-2½" x 3'-8½"	6'-0" x 3'-6½"	5'-10" x 3'-5½"	5'-9" x 3'-5"	5'-8" x 3'-4½"
Sq. ft. of pavement removed for Anchor Special.	27.8	25.8	23.0	21.2	20.2	19.7	19.1
Opening in pavement for a Cross	6'-10½" x 5'-6½"	6'-7½" x 5'-3½"	6'-4½" x 5'-0½"	5'-10½" x 4'-6½"	5'-8½" x 4'-4½"	5'-6½" x 4'-2½"	5'-4½" x 4'-0½"
Sq. ft. of pavement removed for Cross.	38.1	35.0	32.2	26.7	24.9	23.3	21.7

Analysis of Pavements Replaced.

The amount of pavement replaced is found by adding the neccessary percentages as shown in above table to the amount of pavement removed.

Medina Dressed Stone Tar Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	8.75	8.51	8.28	7.56	7.32	7.20	7.07
Variator.	79.20	71.85	69.55	66.10	64.37	62.64	60.77
Anchor special.	49.68	46.37	42.05	39.02	37,30	36.58	35.57
Cross.	68.11	63.07	58.32	49.25	46.37	43.77	40.89

Medina Dressed Stone Cement Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	5.75	5.52	5.30	4.65	4.43	4.33	4.22
Variator.	59.54	54.47	52.00	49.01	47.45	46.41	44.59
Anchor Special.	36.14	33.54	29.90	27.56	26.26	25.61	24.83
Cross.	49.53	45.50	41.86	34.71	32.37	30.29	28.21

Medina Common Stone Tar Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	8.69	8.45	8.22	7.51	7.26	7.15	7.02
Variator.	78.65	71.36	69.07	65.64	63.06	62.20	60.35
Anchor Special.	49.33	46.04	41.75	38.75	37.04	36.33	35.32
Cross.	67.64	62.63	57.91	48.90	46.05	43.47	40.61

Medina Common Stone Sand Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	9.67	9.40	9.14	8.35	8.08	7.95	7.81
Variator.	87.45	79.34	76.80	72.98	71.07	69.16	67.10
Anchor Special.	54.85	51.20	46.43	43.29	41.18	40.38	39.27
Cross.	75.21	69.64	64.39	54.38	51.20	48.33	45.15

Brick Tar Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	9.24	8.98	8.74	7.98	7.72	7.60	7.46
Variator.	83.60	75.85	73.42	69.77	67.94	66.12	64.14
Anchor Special.	52.44	48.94	44.38	41.19	39.37	38.61	37.54
Cross.	71.90	66.57	61.56	51.98	48.94	46.31	43.17

Brick Cement Filled.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	6.14	5.91	5.67	4.97	4.84	4.63	4.52
Variator.	63.66	58.24	55.60	52.40	50.73	49.62	47.68
Anchor Special.	38.64	35.86	31.97	29.47	28.08	27.38	26.55
Cross.	52.96	48.65	44.76	37.11	34.61	32.39	30.16

Asphalt.

	20"	18"	16"	12"	10"	9"	8"
Lineal feet of trench.	6.01	5.78	5.55	4.87	4.64	4.53	4.42
Variator.	62.29	56.98	54.40	51.27	49.64	48.55	46.65
Anchor Special.	37.81	35.09	31.28	28.83	27.47	26.79	25.97
Cross.	51.82	47.60	43.79	36.31	33.86	31.69	29.51

The method used in estimating the paving removed and relaid for manholes is the same as that which has been described for the steam mains,however, there is no standard size opening that will fill all cases as the size of a man hole will entirely depend upon local conditions. The writer recommends,however,that sufficient space be given when building manholes so that the workmen will have ample room when working in same,also proper provision should be made for ventilation. This may be accomplished by installing a vent pipe of sufficient size from midway of vertical wall to curb line and extending approximately ten feet above same. This has been found to be a very satisfactory as well as inexpensive method of removing the obnoxious gases which are always found to accumulate in heated manholes.

The writer has arrived at an average size manhole opening in the street by averaging the sizes of all manholes installed in the system and the result is shown herewith.

The average length of all steam manholes was obtained by adding together the length of all manholes and dividing by the number. In the same manner the average width and depth was obtained.

No. of Manholes.	Inside Dimensions.			Outside Dimensions.		
	Length	Width	Depth	Length	Width	Depth
98	506.24	363.64	888.20	652.54	510.64	888.20
Average	5.16	3.71	9.06	6.65	5.21	9.06
4" added for sheeting				6.93	5.54	

This gives an average manhole opening of 6.93' x 5.54', equivalent to an area of 38.39 square feet. The repaving is estimated from the above added percentages with a deduction, however, being made, corresponding to the size of the cast iron cover which is approximately 4.2 square feet.

In estimating the material to be used for enclosing fittings the writer has compiled the following tables from actual dimensions of fittings with proper clearances.

Variators.

Size.	Dimension of fitting.			Dimension inside box.			Dimension outside box.		
	Length	Width	Depth	Length	Width	Depth	Length	width	Depth
20"	3.35'	2.16'	3.35'	5.35'	3.66'	4.35'	6.85'	5.16'	4.35'
18"	3.19'	2.11'	3.19'	5.19'	3.61'	4.19'	6.69'	5.11'	4.19'
16"	3.02'	2.02'	3.02'	5.02'	3.52'	4.02'	6.52'	5.02'	4.02'
12"	2.67'	1.90'	2.67'	4.67'	3.40'	3.67'	6.17'	4.90'	3.67'
10"	2.47'	1.86'	2.49'	4.49'	3.36'	3.49'	5.99'	4.86'	3.49'
9"	2.45'	1.79'	2.45'	4.45'	3.29'	3.45'	5.95'	4.79'	3.45'

Size	No.of brick.	Cu. Yds. concrete cover.	Board feet of 2"plank.	Sacks of cement.	Tons of stone.	Cu.Yds. of sand.	Bales of shavings.
20"	1370	0.5	70	11.5	.50	2.0	5
18"	1295	0.4	68	10.5	.50	1.5	4.5
16"	1210	0.4	64	10.0	.50	1.4	4
12"	1050	0.4	60	9.0	.50	1.3	3
10"	975	0.4	58	8.5	.50	1.2	2.5
9"	955	0.3	56	8.0	.25	1.1	2.5

Anchor Special.

	Dimensions of fitting			Dimensions inside box			Dimensions outside bo		
Size	Length	Width	Depth	Length	Width	Depth	Length	Width	Depth
20"	1.50'	2.46'	2.83'	2.50'	3.96'	3.83'	4.00'	5.46'	3.83'
18"	1.83'	2.25'	2.50'	2.33'	3.75'	3.50'	3.83'	5.25'	3.50'
16"	1.21'	1.70'	2.25'	2.21'	3.25'	3.25'	3.71'	4.75'	3.25'
12"	1.04'	1.52'	1.83'	2.04'	3.02'	2.83'	3.54'	4.52'	2.83'
10"	.96'	1.34'	1.59'	1.96'	2.84'	2.50'	3.46'	4.34'	2.50'
9"	.90'	1.22'	1.42'	1.90'	2.73'	2.42'	3.40'	4.22'	2.42'

Size	No.of brick	Cu. Yds. concrete cover.	Board feet of 2"plank.	Sacks of cement.	Tons of stone.	Cu.Yds of sand.	Bales of shavings.
20"	910	0.3	42	7.5	.25	1.1	4.5
18"	795	0.3	40	6.5	.25	1.0	4.0
16"	675	0.2	34	5.5	.25	0.8	3.5
12"	555	0.2	32	4.5	.25	0.7	2.5
10"	470	0.2	30	4.0	.25	0.6	2.0
9"	445	0.2	28	4.0	.25	0.6	2.0

Cross or Tee.

	Dimension of fitting			Dimension inside box			Dimension outside box		
Size	Length	Width	Depth	Length	Width	Depth	Length	Width	Depth
20"	3.04'	3.04'	2.33'	4.54'	4.04'	3.33'	6.04'	5.54'	3.33'
18"	2.79'	2.79'	2.08'	4.27'	3.79'	3.08'	5.77'	5.29'	3.08'
16"	2.54'	2.54'	2.00'	4.04'	3.54'	3.00'	5.54'	5.04'	3.00'
12"	2.04'	2.04'	1.63'	3.54'	3.04'	2.63'	5.04'	4.54'	2.63'
10"	1.88'	1.88'	1.33'	3.38'	2.88'	2.33'	4.88'	4.38'	2.33'
9"	1.71'	1.71'	1.25'	3.21'	2.71'	2.25'	4.71'	4.21'	2.25'

Size	No. of brick.	Cu. Yds. concrete cover.	Board feet of 2" plank.	Sacks of cement.	Tons of stone.	Cu. Yds. of sand.	Bales of shavings
20"	1005	0.4	66	8.5	.50	1.2	3.0
18"	883	0.4	60	7.5	.50	1.1	3.0
16"	815	0.3	56	6.5	.25	1.0	2.5
12"	625	0.3	46	5.5	.25	1.0	2.0
10"	540	0.3	42	5.0	.25	0.7	2.0
9"	500	0.2	39	4.0	.25	0.7	2.0

Costs.

All costs shown herewith have been compiled by using the estimated cost of an average job; that is, a job assumed for each of the different sizes of mains equivalent to the average of all jobs of that size installed during a period of three years. These costs have been found to be very conservative for estimating new jobs of any given length under similar conditions.

The following figures show the extent of the mains installed under the writer's service and from which the date shown herewith has been obtained.

20 inch mains		8500 feet	
18	" "	700	"
16	" "	11000	"
12	" "	5900	"
10	" "	1300	"
9	" "	5400	"

The sub-surface soil in the territory of this steam distributing system was over 90 percent sand of an average firmness.

Costs for Trenching.

In arriving at an estimate for this work good judgment and long experience on the part of the Engineer are essential. However the following analyses of jobs installed as described above will present typical problems as well as methods of procedure for work of this character.

In following the analyses the amount of excess excavated material to be removed from the job was determined by the displacement of the main, that is, the cubic yards occupied by casing, fitting boxes and manholes. This was removed to a public dump at an average distance of 1¼ miles which allowed about six loads per day for each wagon.

Estimate of Cost of Trenching for 20 inch Mains, Description.

Average length of jobs 880 feet

Average depth of trenches 9'8"

Labor

1 Foreman		$4.50	per day
1 Sub-foremam		2.75	" "
1 Transitman		3.00	" "
1 Rodman		2.75	" "
6 Laborers	@$2.50	15.00	" "
50 "	@ 2.25	112.50	" "
2 Day watchmen	@2.25	4.50	" "
2 Night watchmen	@ 2.50	5.00	" "
		150.00	" "

Total labor for 25 days to do a job of this size- $3750.00

Labor cost per foot of trench - 4.26

Cartage

Excess excavated material to be remeved approximately 360 cubic yards, requiring,

2 Grade wagons 16 days @ $6.00	$192.00
For hauling sheeting, pipe, fittings etc.	
1 Truck 26 days @ $6.00	156.00
	348.00

Cartage cost per foot of trench- .40

Incidental material.

500 pcs. of 3" x 12" x 12' Hemlock	@ $29.00	$348.00	
Less salvage of 20%		69.60	
			278.40
45 pcs. of 6" x 8" x 10'-0" Hemlock	@ $29.00	104.40	
6 " " 2" x 6" x 10'-0" "	@ 29.00	1.74	
		106.14	
Less salvage of 35%		37.15	
			68.99
100 lbs. of spikes	@ $3.25		3.25
125 gals.of kerosene	@ .08½		10.63
25 days use of city water hydrant	@ .20	5.0	5.00
25 " of miscelleanous expense	@ .50		12.50
			377.77
Incidental Material cost per foot of trench			.43
City inspector 25 days	@ $5.17		129.25
Inspection cost per foot of trench			.15

Estimate of cost of trenching for 18 inch mains

Description

Average length of jobs	365 feet
Average depth of trenches	9'-2"

Labor

1 Foreman		$4.50 per day
1 Subforeman		3.75 " "
1 Transitman		3.00 " "
1 Rodman		3.75 " "
6 Laborers	@ $2.50	15.00 " "
50 "	@ 2.25	112.50 " "
2 Day watchmen	@ 2.25	4.50 " "
2 Night watchmen	@ 2.50	5.00 " "

Total labor for 10 days	$1500.00	
Labor cost per foot of trench	4.11	

Cartage

Excess excavated material to be removed approximately 150 cubic yards, requiring,

2 Grade wagons 6½ days @ $6.00 -	78.00	
For hauling sheeting, pipe, fittings,etc.		
1 Truck 11 days @ 6.00	66.00	
Cartage cost per foot of trebch -	.39	

Incidental Material

200 pcs. of 2" x 12" x 12'-0 Hemlock @ 29.00-	139.00	
Less salvage of 20%	27.80	
		111.20
20 pcs. of 6" x 8" x 20'-0" Hemlock @ 29.00	46.40	
5 " " 2" x 6" x 10'-0" " @ 29.00	1.45	
	47.85	
Less salvage of 35%	16.75	
		31.10
50 lbs. of spikes @ 2.25		1.13
50 gal.of kerosene oil @ .08½		4.25
10 days use of city water hydrant @ .20		2.00
10 days of miscelleanous expense @ .50		5.00
		154.68
Incidental Material cost per foot of trench-		.43

Inspection

1 city inspector 10 days @ 5.17		51.70
Inspection cost per foot of trench		.14

Estimate of cost of trenching for 16 inch mains.

Description.

Average length of jobs	1134 feet
Average depth of trenches	9'-4"

Labor

1 Foreman		$4.50	per day
1 Sub-foreman		3.75	" "
1 Transitman		3.00	" "
1 Rodman		2.75	" "
6 Laborers	@ $ 2.50	15.00	" "
50 "	@ 2.25	112.50	" "
2 Day watchmen	@ 2.25	4.50	" "
2 Night watchmen	@ 2.50	5.00	" "
		150.00	" "

Total labor for 28 days $4200.00

Labor cost per foot of trench 3.70

Cartage

Excess excavated material to be removed approximately 360 cubic yards, requiring,

2 Grade wagons	$180.00
For hauling sheeting, pipe, fittings, etc.,	
1 Truck 29 days @ 6.00	174.00
	354.00

Cartage cost per foot of trench .31

Incidental Material

600 pcs. of 2" x 12" x 12'-0" Hemlock @ 29.00- 417.60

Less salvage of 20% 83.52

334.08

67 pcs.of 6" x 8" x 20'-0" Hemlock @ 29.00-	155.44	
10 pcs. of 2" x 6" x 10'-0" " @ 29.00-	2.90	
	158.34	
Less salvage of 35%	55.42	
		102.92
125 lbs. of spikes @ 2.25		2.81
125 gal. of kerosene oil @ .08½		10.63
28 days use of city water hydrant @ .20		5.60
28 " of miscelleanous expenses @ .50		14.00
		470.04
Incidental material cost per foot of trench		.42

Inspection

1 city inspector 28 days @ 5.17	144.76
Inspection cost per foot of trench	.12

Estimate of cost of trenching for 12 inch mains.

Description

Average length of jobs	755 feet
Average depth of trenches	8'-3"

Labor

1 Foreman	$4.50 per day	
1 Sub-foreman	2 2.75 " "	
1 Transitman	3.00 " "	
1 Rodman	2.75 " "	
6 Laborers @ 2.50	15.00 " "	
50 " @ 2.25	112.00 " "	
2 Day watchmen @ 2.25	4.50 " "	
2 Night watchmen @ 2.50	5.00 " "	
	150.00 " "	
Total labor for 15 days		2250.00
Labor cost per foot of trench		2.98

Cartage

Excess excavated material to be removed approximately 175 cubic yards, requiring,

3 Grade wagons 7½ days @ 6.00	90.00		
For hauling sheeting, pipes, fittings, etc.,			
1 Truck 15 days at 6.00	90.00		
	180.00		
Cartage cost per foot of trench	.24		

Incidental Material

400 pcs. of 2" x 12" x 10'-0" Hemlock @$29.00		232.00	
Less salvage of 20%		46.00	
			185.60
40 pcs. of 6' x 8" x 20'-0" Hemlock @ $29.00		92.80	
5 " " 2" x 6" x 10'-0" " @ 29.00		1.45	
		44.25	
Less salvage of 35%		32.98	
			61.27
80 lbs. of spikes @ 2.25			1.80
75 gal. of kerosene @ .08½			6.37
15 days use of city water hydrant @ .20			3.00
15 " miscelleanous expense @ .50			7.50
			265.54
Incidental material cost per foot of trench			.35

Inspection

1 City inspector 15 days @ 5.17	77.00
Inspection cost per foot of trench	.10

Estimate of cost of trenching for 10 inch mains.

Description

Average length of jobs	250 feet
Average depth of trenches	7'-6"

Labor

1 Foreman		$4.50	per	day
1 Sub-foreman		2.75	"	"
1 Transitman		3.00	"	"
1 Rodman		2.75	"	"
4 Laborers	@ 2.50	10.00	"	"
40 "	@ 2.25	90.00	"	"
2 Day watchmen	@ 2.25	4.50	"	"
2 Night watchmen	@ 2.50	5.00	"	"
		122.50	"	"

Total labor for 5 days	612.50
Labor cost per foot of trench	2.42

Cartage

Excess excavated material to be removed approximately 48 cubic yards, requiring,

1 Grade wagon 4 days	@ 6.00	$24.00
For hauling sheeting, pipe, fittings, etc.,		
1 Truck 5 days	@ 6.00	30.00
		54.00

Cartage cost per foot of trench	.21

Incidental material

130 pcs. of 2"x12" x10'-0" Hemlock @ $29.00-75.40			
Less salvage of 20%	15.08		
		60.32	
15 pcs. of 6"x 8"x20'-0" Hemlock @ 29.00-34.80			
3 " " 2"x 6"x 10'-0" " @ 29.00-	.87		
	35.67		
Less salvage of 35%	12.48		
		23.19	
30 lbs. of spikes @ 2.25		.68	
20 gal. of kerosene oil @ .08½		1.70	
5 days use of city water hydrant @ .20		1.00	
5 " miscelleanous expense @ .50		2.50	
		89.39	
Incidental material cost per foot of trench			.35

Inspection

1 City inspector 5 days @5.17	$25.85
Inspection cost per foot of trench	.10

Estimate of cost of trenching for 9 inch mains.

Description

Average length of jobs	535 feet
Average depth of trenches	7'-10"

Labor

1 Foreman	$4.50	per day
1 Sub-foreman	2.75	" "
1 Transitman	3.00	" "
1 Rodman	2.75	" "
4 Laborers @ 2.50	10.00	" "
40 " @ 2.25	90.00	" "
2 Day watchmen @ 2.25	4.50	" "
2 Night watchmen @ 2.50	5.00	
	122.50	" "
Total labor for 10 days		$1225.00
Labor cost per foot of trench		2.29

Cartage

Excess excavated material to be removed approximately 80 cubic yards, requiring,

1 Grade wagon 7 days @ 6.00 $42.00

For hauling sheeting, pipe, fittings, etc.,

1 Truck 11 days @ 6.00 66.00

108.00

Cartage cost per foot of trench .20

Incidental Material

250 pcs. of 2"x 12"x 10'-0" Hemlock @ $29.00- $145.00

Less salvage of 20% 29.00

116.00

28 pcs. of 6"x 8"x 20'-0" Hemlock @ 29.00- 64.96

5 pcs. of 2"x 6"x 10'-0" Hemlock @ 29.00- 1.45

66.41

Less salvage of 35% 23.24

43.17

50 lbs. of spikes @ 2.25 1.13

50 gal. of kerosene oil @ .08½ 4.25

10 days use of city water hydrant @.20 2.00

10 days miscellaneous expense @.50 5.00

171.55

Incidental material cost per foot of trench .32

Inspection

1 City inspector 10 days @ 5.17 51.70

Inspection cost per foot of trench .10

The following table is a summary of the above analyses and has been found to be remarkably accurate for estimate work.

Cost per lineal foot of trench.

Size	Labor	Cartage	Incidental material	Inspection
20"	4.26	.40	.43	.15
18"	4.11	.39	.43	.14
16"	3.70	.31	.42	.12
12"	2.98	.24	.35	.10
10"	2.42	.21	.35	.10
9"	2.29	.20	.32	.10

Analysis of labor cost for pipe laying.

These estimates are based on local union scale, that is, it was found impossible to employ other than union men, for these reasons the unit prices are usually higher than would be experienced in smaller cities.

20 inch pipe.

Average length of jobs	880 feet
Labor	
1 Boss Steam fitter	$5.60 per day
2 Fitters @ 2.80	5.60 " "
8 Laborers @ 2.25	18.00 " "
1 Sewer builder	4.50 " "
	33.70 " "
Total labor 24 days	808.80
Labor cost per foot of pipe	.92

18 inch pipe.

Average length of jobs 365 feet

Labor

Same labor unit as for 20" pipe -- $33.70 per day

Total labor 9 days- 303.30

Labor cost per foot of pipe- .83

16 inch pipe.

Average length of jobs. 1134 feet

Labor

Same labor unit as for 20" pipe - $33.70 per day

Total labor 27 days- $909.90

Labor cost per foot of pipe.80

12 inch pipe.

Average length of jobs 755 feet

Labor

Same labor unit as for 20" pipe - $33.70 per day

Total labor 13 days - $438.10

Labor cost per foot of pipe .58

10 inch pipe.

Average length of jobs 250 feet

Labor

1 Boss steam fitter	$5.60	per day
2 Fitters @ $2.80	5.60	" "
6 Laborers @ 2.25	13.50	" "
1 Sewer builder	4.50	" "
	29.20	" "

Total labor 4½ days 131.40

Labor cost per foot of pipe .50

9 inch pipe.

Average length of jobs	535 feet
Labor	
Same labor unit as for 10 inch pipe--	$ 29.20 per day
Total labor 9 days	262.80
Labor cost per foot of pipe	.49

Cost of Removing Pavements in Cents per Square Foot.

In arriving and compiling the following table on the costs of removing various kinds of pavement per square foot, the writer made use of results obtained by noting the actual amount of pavement removed, and necessary expense involved in removing same, for 90% of the jobs done in three years. Thus, during the process of a job from six to twelve laborers @ $2.25 a day with a foreman @ $2.75 a day were detailed to remove the pavement in advance of the trenching gang. To the average labor costs of this work was added a percentage for accounting (.30%), construction superintendence (2.9%) and tools (3.3%) to obtain the total cost.

The removing of cement filled pavements was found to have a greater cost than the other types, due to the cementing to-gether of the blocks or bricks, to-gether with the concrete mat beneath.

Labor costs of removing various kinds of pavements in cents per square foot.

Medina Dressed Stone Tar filled	$.015
Medina Dressed Stone Cement Filled	.066
Medina Common Stone Tar Filled	.015
Medina Common Stone Sand Filled	.009
Brick Tar Filled	.013
Brick Sand Filled	.063
Asphalt	.056

The above unit cost per square foot have been found to be remarkably accurate for this class of work.

Costs of Replacing Pavements in Cents per Square Foot.

As all of the paving is relaid either by the Municipal Authorities or by Contractors on guaranteed jobs, and the actual cost billed the company, the writer took the average of the billed costs for the various kinds of pavements relaid for the three years in compiling the following table on costs per square foot.

The total cost of repaving is made up by adding to the average billed costs a percentage for accounting and construction superintendance. These charges are for the time of the accounting force that is taken to handle the bills and for a part of the time of the Construction Superintendant and his assistance. Included in this cost is all the time of the Company paving inspector who is engaged in checking the quantities on the bills.

Labor and material costs of relaying variou kinds of pavements in cents per square foot(all old paving used as far as possible).

Kind	1. Average billed cost	2. Construction Superintendence 2.9%	3. Accounting .3% of 1&2	4. Total cost
Medina Dressed Stone Tar Filled	.1405	.0041	.0004	.1450
Medina Dressed Stone Cement Filled	.3566	.0103	.0011	.3680
Medina Common Stone Tar Filled	.0908	.0026	.0003	.0937
Medina Common Stone Sand Filled	.0658	.0019	.0002	.0679
Brick Tar Filled	.1801	.0052	.0005	.1858
Brick Cement Filled	.2796	.0081	.0008	.2885
Asphalt	.2337	.0068	.0007	.2412
Wood Block	.3400	.0099	.0010	.3509
Cement Walk	.1200	.0035	.0004	.1239

Labor Material Cost of Laying Concrete Mat in cents per Square Foot.

As before mentioned that the above unit costs of relaying pavements do not include the costs of laying concrete mat, it is necessary to estimate a separate cost for the mat and apply to all repaving where the mat is found.

The cost of material per square foot of mat as delivered on the street at the point of use was,

Cement	.021 bbl. x $1.65 -	$.0347
Sand	.0096 cu. yds. x 1.00 -	.0096
Stone	.0198 Tons x 1.60 -	.0317
	Total	.0760

The cost of labor for placing the concrete mat, mixing with a steam concrete mixer and distributing in buggies, placing and tamping by hand, was estimated on an average output of 20 cu. yds. per day equal to 1080 Sq. ft. of mat in place, with the following gang:

1 Foreman		@ 2.75	per day
1 Engineer		@ 2.75	" "
1 Fireman		@ 2.50	" "
14 Laborers	@2.25	31.50	" "
		39.50	" "

or labor cost per sq. ft. of mat of $.0366

A certain amount of incidental material such as coke for mixer, cylinder oil, lubricating oils, kerosene, waste and water was charged to the laying of concrete mat and was found to be an average expense of $1.50 a day or an incidental charge per square foot of mat of .0014

There was no charge for cartage on the cement, sand, and stone as this was dilivered free at the price quoted. It was necessary, however, to allow for the cost of bringing the concrete mixer, buggies and other tools to the job, moving the same from place to place and finally returning same to yard. It was found that this approximated very cloeely to a team and driver's time for a half day every day that the gang was working or $3.00 a day or a charge per square foot of mat of .0028. It was also necessary to have a city inspector for every day working and his charge accounted like-wise namely $5.17 or a charge per square foot of mat of .0048.

Summing these charges up give us the cost of concrete mat laid per square foot , which must be added to the repaving unit price where found

Material	$.0760	per sq. ft.
Labor	.0366	" " "
Incidentals	.0014	" " "
Cartage	.0028	" " "
Inspection	.0048	" " "
	.1216	

Labor and Material Costs of Manholes.

The estimating of the cost of building a manhole is a variable factor as the manhole is entirely dependent upon local conditions. The writer has investigated the costs of some eighty different manholes that have come under his supervision and has arrived at an average cost of $110.00 per manhole. This cost including brickwork for the sides, concrete for the bottom and top, old iron tee rails for roof supports, sewer connection and permits, sewer grates, manhole frame and cover, supervision and incidentals.

Labor and Material Costs for Insulating fittings with John Manville Prepared Covering.

This cost was on a contract bases and averaged a unit price of 45 cents per square foot of external surface. The following table, compiled from the actual measured external surfaces of the various fittings, gives the costs of insulating underground fittings.

Size	20"	18"	16"	12"	10"	9"
Double Variator	$13.95	$13.50	$13.05	$10.80	$10.35	$9.00
Single Variator	13.05	12.15	11.25	9.90	8.55	8.10
Anchor Special	7.65	7.00	6.30	4.95	4.05	3.60
Cross	14.40	12.40	10.35	6.75	5.40	4.50
Tee	12.15	10.35	8.55	5.40	4.50	3.60
Valve	6.75	5.40	4.05	2.70	2.25	1.35
Angle Joint	6.75	5.60	4.50	3.15	2.25	2.25

In conclusion, the writer will give a general form for estimating the cost of a Steam Main. This form has been used in practice for several years by the writer and has been accepted by several Central Station Steam Companys throughout the country. Although this form only covers the field of work in a typical way yet is applicable to any size main or section of mains.

ESTIMATE.

For all necessary labor and material for installing a -- inch steam main on ------------ street, from -------- to --------; Length of main ------ feet; Average depth of trench --- feet.

MATERIAL.

No.		Price		Costs
----	feet of 20 " wrought iron pipe	@ --.--	per ft.	---.--
----	" " $22\frac{3}{4}$" inside diameter casing	@ --.--	" "	---.--
---	20" Double Variators	@ --.--	each	---.--
---	20" Single "	@ --.--	"	---.--
---	20" Anchor Specials	@ --.--	"	---.--
---	20" " Base Crosses	@ --.--	"	---.--
---	20" " " Tees	@ --.--	"	---.--
---	20" Iron body gate valves	@ --.--	"	---.--
---	20" Angle joints	@ --.--	"	---.--
---	20" Adjustable Annular Wedges	@ --.--	"	---.--
---	20" Standard Flanges	@ --.--	"	---.--
---	20" Blind Flanges	@ --.--	"	---.--
---	20" Corrugated Copper Ring Gaskets	@ --.--	"	---.--
---	20" Modle C Collars	@ --.--	"	---.--
---	20" Guides with rollers	@ --.--	"	---.--
---	lbs. of Asbestos paper	@---.--	per lb.	---.--
---	" " No 19 pliable copper wire	@ --.--	" "	---.--
---	" " Asphalt	@ --.--	" "	---.--
---	Rolls of Tarred Roofing 3-ply	@ --.--	" roll	---.--
---	Size --- Steam Traps	@ --.--	each	---.--

INSULATING MATERIAL

Material for enclosing --- Variators, --- Anchor Specials, ---- Crosses, --- Tees, ---- Angle Joints.

---- Bricks	@ ----	per M		---.--
---- Sacks of Portland Cement	@ ----	"	sack	---.--
---- Tons of crushed Stone	@ ----	"	ton	---.--
---- Bd. Ft. of Hemlock Planking	@ ----	"	M.Bd.Ft.	---.--
---- Bales of shaving	@ ----	"	bale	---.--

TRENCHING.

Labor	for	----	ft.	of	trenching	@ ---	per	ft.	---.--
Cartage	"	----	"	"	"	@ ---	"	"	---.--
Inspection	"	----	"	"	"	@ ---	"	"	---.--
Incidental	Material	----	"	"	"	@ ---	"	"	---.--
Piping	for	----	"	"	"	@ ---	"	"	---.--

PAVING.

					Kind of pavement						
Removing	----	Sq	ft	of	-------------	pavm't	@ ----	per	~~lr~~ sq.	ft	--.-
"	----	"	"	"	-------------	"	@ ----	"	"	"	--.-
"	----	"	"	"	-------------	"	@ ----	"	"	"	--.-
Relaying	----	"	"	"	-------------	"	@ ----	"	"	"	--.-
"	-----	"	"	"	-------------	"	@ ----	"	"	"	--.-
"	----	"	"	"	-------------	"	@ ----	"	"	"	--.-

Concrete Mat.

Material	cost	for	----	sq.ft.	of	concrete	mat	@ ---	per	sq	ft	--.--
Labor	"	"	----	"	"	"	"	"	@ ---	"	"	"	--.--
Cartage	"	"	----	"	"	"	"	"	@ ---	"	"	"	--.--
Inspection	"	"	----	"	"	"	"	"	@ ---	""	"	"	--.--

Man Holes.

Labor and Material for ---- manholes @ $110.00 per manhole ---.--

Total Estimate Cost ---.--

plus 15% ---.--

[redacted]