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SOME NOTES ON MACADAM ROADS AND PAVEMENTS

MODERN NECESSITIES FOR VARIED HIGHWAY TRAFFIC—NEW DESTRUCTIVE FORCES AND AGENCIES TO MEET THEM—PAVING MATERIALS AND THEIR CHARACTERISTICS

By FRED. L. MACPHERSON, A.M. Inst. C.E., A.M. Can. Soc. C.E.,

Municipal Engineer, Burnaby, B.C.

Of paramount interest to any public body is the vital and far-reaching question of transportation. Next to transportation by rail and water, comes transportation by road—the one being the logical outcome and veritable necessity of the other. Railways are first in the early development of any country, but without a comprehensive system of trunk highways as feeders to the railways further development of the country is hampered and progress impeded. Recently there has been a revival of the road-building problem and the "Good Roads movement" is receiving the attention it deserves, not only from municipal bodies and provincial and federal authorities, but also from the general public. Good roads are essentially a business proposition; commercial, industrial, agricultural, and social conditions are all directly or indirectly benefitted by them. They are not only an index of, but also a means towards, a country's greatness and prosperity. They result in the cheapening of transportation, improved marketing facilities, increased land values, and the betterment and extension of social conditions and privileges. Much has been said about the indifferent agricultural conditions existing in the Fraser Valley districts. Obviously enough, the remedy lies in providing more and better transportation facilities by road. Railways and car lines, while materially assisting, do not, and cannot, in themselves supply the largely felt needs of cheap, speedy and effective transportation direct between our fruit and dairy farms and our towns and cities. Increase our mileage of roads, improve our existing roads, afford our farmers and fruit-growers an opportunity to compete on equal conditions with fruit-growers, and not only do we decrease the high cost of living, but we also prosper and populate our fertile fruit and farm lands. Assuredly development and progress will go hand in hand with the provision for better means of highway transportation. Due stress has been laid on *good* roads. The roads which were good enough a few years ago are now indifferent, some of them even bad. With the drastic change in traffic conditions the former methods of construction of arterial highways are either materially changing or fast becoming obsolete. The time is at hand when country roads will be subjected to as heavy traffic conditions and as severe usage as are city streets. Country roads, being generally narrow and highly crowned, the traffic is concentrated on the central portion of the roadway, whereas on the wide city street the traffic is scattered, conditions which are further aggravated by the greater speed allowed on country roads than on city streets. In view of such facts, and in the very force of circumstances, it seems natural to conclude that the same care, discretion and skill which is now exercised in the designing and construction of city pavements should also be extended to the planning and building of the much-travelled main highways. The problem at issue, therefore, appears to be the construction at a reasonable cost of a modified paved highway which will combine the utility and durability of the paved street and yet retain the aesthetic and attractive features of a rural road.

Few, if any, of us wish to see our rural highways converted into the stereotyped paved street, for apart from their mere utilitarian objects there is much that is naturally attractive and appealing to the motorist and pleasure seeker in the ordinary rural highway, with its straight, level stretches, joined by easy, graceful curves, succeeded by undulations peculiar to a rolling country. The conception and construction of the more modern highway should, therefore, be along lines both utilitarian and aesthetic. To develop a highway which will ultimately fulfil all of its requirements one should be governed by the following principles: (1) The building of a road in the best possible location as to line and level. (2) The macadamizing of the road of suitable width and depth. (3) The conversion of such road with a consolidated rock foundation into a bituminous pavement by hard surfacing. Desirable and necessary as paved roads may be, it is not financially possible for most municipal authorities to undertake at the outset a large mileage of permanent roads at a higher first cost. But arrangements can generally be made for the construction at reasonable cost of a good paved road in the above successive steps.

In commenting on roads and pavements, it is natural to first discuss the former and its relationship to the latter. Road or street construction has gone through a period of evolution—the modern paved street of to-day being the logical outcome of the roads of yesterday, just as the modern macadam road has replaced the trails of the pioneer and the prospector of earlier days. Increased traffic, the easy and economical transportation of heavy loads, consequent upon the settlement of the country, made necessary the convertion of the first rough trails blazed through the forest, into passable thoroughfares.

Passable thoroughfares stood the demands of traffic and served the immediate needs of the earlier settlers, but with the rapid development of the country, and the upgrowth of townships and communities, the need for better highways of communication became not only necessary but imperative. A district settled up just as fast as the means of communication were extended, and developments kept pace with the road improvements. In short, roads came before towns and cities, and not until the townships developed into cities by easy stages and through many vicissitudes, did the modern city street as known to us arise and become standardized. In short, good roads and streets and higher civilization go hand in hand, each being interdependent on the other.

Macadam Road Construction.—In treating of macadam roads it is necessary to distinguish between water-bound macadam roads and bituminous-bound macadam roads. The former have been in adoption for about a century, and although the present methods employed in building water-bound macadam roads are entirely different, owing to the introduction of labor-saving devices, the principles underlying their construction are essentially the same. The first requisites for macadam road construction, namely, drainage, compactness of sub-grade, selection and grading of materials and consolidation of whole, are the same to-day as they were in the pioneer days of road building. The scientific, though commonplace, principles underlying the successful construction of the water-bound macadam road are:—

(1) The compression and compacting by rolling of the different sizes and shapes of broken stone (varying from foundation upwards) by knitting together and interlocking the rough angular surfaces of the stones.

(2) The application thereto by further rolling and sprinkling of a binding course of suitable material to cohere the whole, reduce the voids to the minimum and rended the surface as wearing and as waterproof as possible.

Recognizing such fundamental principles it is not difficult to realize that the satisfactoriness and serviceability of a water-bound macadam road are principally dependent on the preservation intact, and as nearly as possible waterproof, of the wearing surface. The disintegration of water-bound macadam roads is, therefore, chiefly due to the ravelling action consequent upon long spells of drought which dries up the binding material, diminishes its cementing action and lays the aggregate underneath at the mercy of the destructive action of traffic.

The Effect of Speedy Vehicles.—The action of iron tires on slow-moving vehicles was not so severe on, and destructive to, such water-bound macadam roads, and with eternal vigilance necessary repairs could be made at comparatively small expense to keep such road in ordinarily good condition, and with further precautions of scarifying and resurfacing of such roads every two or three years they could generally withstand the ordinary wear and tear of traffic. The forces to which the roads were then subjected were strictly dead and live loads and of course impact, due to action of horses' hoofs and bumping of wheels in ruts and depressions. The speed at which vehicles then travelled being moderate, the live load on the roads was not then so appreciable and the impact not very high. Hence, water-bound macadam roads achieved their precious ends in successfully withstanding such physical forces. There was thus no immediate necessity for any better class of highway to accommodate the travelling public who were at that time generally satisfied.

But with the introduction of the automobile in the last decade, conditions entirely changed and engineers and authorities were confronted with the more serious problem of preserving the surface of the roadbed from the disintegrating and ravelling action of swiftly moving rubber-tired automobiles. The former methods of construction of water-bound macadam roads had necessarily to give place to the adoption of bituminous-bound macadam roads, the second stage in the evolution of the more modern hard-surfaced highway. Not only had the roads then to meet forces due to dead load, live load and impact and all these in a greater intensity, but also the more destructive and disintegrating forces of suction and shear.

Suction is the indirect result of the wind current and vacuum formed at the rear of the tires of a swiftly moving automobile. Such a force, or the resultant of such forces, tends to break the bond, loosen and disturb the binding particles in the surface of the road, and ultimately to disintegrate the roadbed.

Shear is caused by the tractive force exerted by the driven wheels of an automobile and naturally its intensity varies directly with the weight and speed of the automobile. Such a force has also a disintegrating effect on the surface of the roadbed. Since water-bound macadam roads have little or no resistance to the above action of suction and shear, it can readily be seen that it is imperative to build a road with binding material sufficiently strong and cohesive.

The more general use of the automobile also emphasized and increased the dust nuisance, so that attention had to be devoted to the dual problem of the preservation of the wearing surface, and the prevention or elimination of the dust. Various methods of applying different kinds of oils and emulsions, at different degrees of temperature, and under different conditions, have been adopted to bind together and consolidate the rock aggregate of the roadbed, and to abate, if not entirely eliminate, the dust nuisance. While many such preventive methods have met with a measure of success, they cannot be said to be generally and wholly satisfactory. While engineers and road experts are to be congratulated on the skill, ingenuity and resourcefulness, which they have adopted in their determined efforts to construct a bituminous macadam road, at low first cost, of passing serviceability, to meet the new problems associated with the changes of highways traffic, it cannot be justly maintained that the remedies, taking the all-important factor of maintenance into account, have been permanent.

Road Treatments. — The various "treatment" methods in vogue have afforded a temporary measure of relief, but as their ultimate success depends on frequent treatment, they are at the best only make-shifts, and costly at that. Referring to the oiling of roads, this was first adopted in California, where the local residual oils were used to counteract the destructive influences of the long drought on water-bound macadam roads, for while generally speaking water-bound macadam roads are not adapted to a humid climate, such as portions of the Pacific Coast, they are equally unsuited to such a dry climate as California. As already stated, a certain amount of moisture and dampness is necessary to keep the binding materials intact. The highest authorities agree that the best oil to adopt is a pure oil, unmixed with any other oils, and one having a natural asphaltic base. It is the asphaltic properties in road oils which, mixed with the aggregate or injected into the roadbed, binds the materials together and hold them in place, thus preventing, or at least reducing, the ravelling of the roadbed. The best results are produced if a heavy road oil is used after the road has been partially rolled and previous to the laying of the binder course of fine rock or coarse sand. In this way the asphaltum in the oil gets thoroughly incorporated with the component parts of the roadbed which are bound together and interlocked. Successful results have also been achieved in mixing the rock and asphaltic oil together in an ordinary concrete mixture before laying it down. The application of from one-third to one-half gallon of road oil per square yard to the wearing surface of an old macadam road tends to preserve it from wearing action and renders the surface more even and waterproof and incidentally lays the dust. But such measures are merely palliatives and dust preventives, comparatively cheap to adopt (2 cents per square yard or $150 per mile for a width of 12 feet) and, moreover, a decided relief to the travelling public and householders during the summer months. With the approach of the wet seasons, however, the roads thus oiled are rendered muddier than ever, and the mud, being of a heavy, plastic nature, is more difficult and costly to remove. The results from surface road oiling are subsequently disappointing and there appears to be something in the contention that the oiling of roads, while preserving the surface in summer, tends to loosen and disintegrate the particles of the roadbed in winter when they are subjected to the trying alternating influences of rain, frost and thaw. Hence, after several seasons of experimenting with surface oiling with different conditions, such as sweeping the roadbed free of all dust and dirt, applying the oil by means of spraying machines under pressure, and in adopting every conceivable device to arrive at the most satisfactory results, the practice of road oiling has been abandoned by many authorities as being too costly.

In their determined efforts to preserve and lengthen the life of macadam roads and to combat the dust, nuisance engineers and authorities have been experimenting for several years back with coal tar in the building of tar-macadam roads. Refined coal tar from gas works, specially treated to remove the injurious constituents and yet to preserve the ductile and bituminous properties of the tar, has been generally employed in the construction of such roads. The methods adopted have varied considerably, but the general principles of construction involve the heating of the stone to drive out the moisture and the mixing by hand or mixer of the stone, and tar heated to a specific temperature. The chief drawbacks to the use of tar on construction of macadam roads are:—

(1) It is difficult to procure commercial tar of uniform quality.

(2) Great care is necessary in the heating of tar, for if heated too much it becomes brittle and loses its ductile properties upon which its virtue depends.

(3) The tar must be uniformly refined—if refined too little the light volatile oils and ammonia will disintegrate it, if refined over much it will be too brittle.

(4) The weather must be warm and dry to successfully use tar macadam.

(5) The roadbed must be perfectly clean and dry. Hence the use of tar-macadam is confined to the summer months.

(6) It is too susceptible to extremes of temperature, being soft and mushy in midsummer heat and too brittle and slippery in cold, frosy weather.

(7) It is not sufficiently dense and durable.

Better results appear to have been procured from tar-macadam roads in the Old Country, probably because of the more uniform and better quality of commercial tars which are there procurable, and also owing to more careful and scientific construction. In this country their adoption has been confined chiefly to eastern cities, where it has been found that, at an average cost of about 50% over the cost of ordinary water-bound macadam roads, fairly satisfactory and serviceable results have been procured for the first two or three years, but that after that period the wearing surface began to develop a mottled appearance and to disintegrate. Tar painting of such broken surfaces to seal the pores and preserve the surface has been tried but without the desired results, and consequently recourse has been had to covering such tar-macadam roads, on which the foundation is good, with a sheet asphalt or some other asphaltic mixture preparation. Hence, owing to the varibility of the results produced, and the shortness of the life of even the best tar-macadam roads, their further adoption has been generally abandoned in favor of some more durable bituminous pavement of greater first cost. The general failure of the use of commercial coal tar led to much experimenting and the result has been the production of a specially distilled coal tar preparation known as "Tarvia." But while its use, when confined to park roads and boulevards, has met with a measure of success, it cannot be maintained that the results produced on its adoption to much-travelled highways has justified its additional cost. As applied to the road surface as a dust preventive, its average cost is 10 cents per square yard, or about $825 per mile for a 14-foot roadbed, and while further treatment can be applied at a correspondingly less cost, taking the cost of periodical treatments into account, it cannot be said to be economical in the long run. Briefly, the process consists in applying to the ordinary macadam formation, under a pressure of about 50 lbs., heavy asphaltic oil containing about 85% of pure asphalt and heated to a temperature of about 220°. The macadam is laid and rolled in two courses; the first course consisting of about 6 inches of 3-inch sized rock, and the second course varying in size from 1-inch to 2-inch rock. To this latter course is applied the heated asphaltic oil, which penetrates throughout the whole of the macadam. On top of this oil is spread a layer of granite screenings varying from ¼ inch to ¾ inch, from which the dust and dirt have been eliminated and the whole mass is then thoroughly consolidated by rolling. Another treatment of oil is then applied, and further granite screenings about 3/16 inch spread and rolled. Judging from results, such an asphaltic treatment appears to produce a compact, elastic roadbed, with a smooth surface of beautiful appearance. While the experiment has only been of comparatively short duration and it remains to be seen whether or no its durability will be proved, the additional cost of about 25% over the ordinary water-bound macadam road fully justifies its more general adoption. It is estimated that such an "oilcrete" road would wear well for about five years, and as it eliminates the need for yearly oiling of an ordinary macadam road, whose life at the most is three years, there is much to be said in its favor.

It will serve no purpose to discuss further any of the other oils, bitumens and special preparations which the ingenuity of engineer and manufacturer have devised in their endeavor to meet the special requirements of this automobile age. Although each manufacturer or inventor claims his particular preparation to be the panacea of road construction, their compositions are all very similar and the methods of use and application vary only slightly.

Reference, however, should be briefly made to an entirely different product, known as "Roc-mac," a solution which has recently been adopted with considerable success in this country after having withstood satisfactory tests in Great Britain. In use it differs essentially from other binding materials inasmuch as its action is purely chemical, whereas the action of the others is more physical. Roc-mac solution is a patented substance which unites chemically with limestone screenings to form a carbonate compound of good binding and adhesive qualities. No heating of any of the materials is required, nor is any special plant necessary for its use. It can be laid during almost any kind of weather and is not greatly affected by extremes of temperature or by weather conditions.

Reference to the above preparations shows that engineers and road experts have been fully alive to the situation, and are confronted with problems which, although seemingly more commonplace than the design and construction of bridges and other structural works, are yet more complex and difficult of solution. In road construction it is a vital matter these days to change with changing circumstances; for instance, road builders had scarcely adjusted themselves to the changed conditions brought about by the swiftly moving automobile, and made what was then considered adequate provision for their requirements, when the motor truck was introduced to further complicate the problem of the construction and maintenance of roads. They are now face to face with a situation which demands not merely remedial measures, but some more or less permanent cure. The motor truck has come and come to stay; the number is certain to increase and multiply, particularly in interurban districts, and the type of road which their heavier and more rumbling loads and their greater impact necessitate, must be built, and built to wear. Neither water-bound nor bituminous macadam roads will, for any length of time, withstand the intensive and irregular stresses produced by heavily loaded and moderately speeded motortrucks. While the foundation of the ordinary macadam roads, particularly where they have been gradually built-up with periodical resurfacing, is likely to be sufficiently strong and rigid, it is imperative that such a foundation be kept intact from the impounding action of motor trucks by means of a sufficiently thick, durable and waterproof surface. Road authorities are consequently turning their attention to the construction of a modified form of city pavement for use on the principal highways.

Advantage of Pavements.—That good street pavements are essential to the highest development of the commercial, sanitary, social and educational life of any city cannot be disputed. To any city or town they are an asset which cannot be computed in mere figures. The hall mark of any city is its good pavements, which attract and impress not only the casual visitor, but the manufacturer or investor bent on introducing industries or investing capital. Pavements are part and parcel of the everyday life of the merchant, the manufacturer and the private citizen—all of whom are affected financially and otherwise according as the pavements are good, bad or indifferent. The beneficent and far-reaching influence of pavements upon the social, aesthetic and commercial life of any community cannot be enlarged upon within the scope of this paper, but briefly the principal advantages derived from the construction of pavements are:—

(1) Tractive power is diminished and the cost of transportation correspondingly decreased—benefits accruing alike to commerce and business.

(2) The fixing of a permanent grade and building line permitting of permanent and uniform improvements to buildings, residential and commercial, fronting on the street—chiefly private benefits.

(3) Increased efficiency of fire protection afforded by the better transportation of fire-fighting apparatus—benefits to the community at large.

(4) Enhanced values of property abutting on streets.

(5) The beautifying of the street through having a regular and uniform appearance as to lines and levels—chiefly aesthetic benefits.

(6) The more efficient sanitation and cleanliness and resultant healthfulness, the dust and mud problem being to a great extent eliminated—sanitary benefits.

(7) The furtherance of pleasure driving and thereby the promotion of social intercourse—community benefits.

In short, on business streets, good pavements are an indispensable necessity to good business and commerce; on residential streets they naturally add to the comfort, pleasure and health of the community. Reference was made to *good* pavements as it cannot be contended that any or all classes of pavements confer the above benefits on the life of public and private citizens. The next important question is, therefore, the selection of a type of pavement which will meet with the special requirements of the location and be suitable for the purposes to which it is to be more particularly put. This selection of a pavement is a contentious matter upon which divergent opinions obtain, depending upon whether they are looked at from the standpoint of the individual property owners, the manufacturers or promoters of the pavement, and last but not least the standpoint of the engineer in charge. As the bulk of the paving work in cities is done under local improvement, the determination of the kind of paving material to be used lies almost wholly with the property owners, the opinion of the majority of whom must prevail. This system is, therefore, open to criticism and tends to abuse of privileges as it means that the whims of property owners are assented to and a class of pavement laid on an objectionable layout which is frequently not suitable from an economic or engineering standpoint —being cheap in first cost, or entirely unsuited to the grades of the street. Utilitarian, not sentimental, principles should be given first consideration. The adoption of a type of pavement best adapted to the city as a whole or to any particular kind of street is frequently entirely overlooked. No particular type of pavement is equally adapted to meet the requirements of all cities, nor is any one kind of pavement suited to all the streets in the same city. The needs of each city should be specially studied, just as the needs of each street in any city should receive particular attention. The present and prospective uses of the street, the relative location to existing pavements, the traffic conditions, present and probable, the nature and kinds of materials available, the nature of the subsoil, the cross and longitudinal grades—all these are highly important factors to be considered in determining the best pavement to be adopted for any particular street. Commonplace and commonsense as are all of such matters, infrequently they are either wholly or partially disregarded.

The most important factors which should govern the design of city pavements, are those affecting the health and comfort of the citizens in eliminating, as far as possible, the nuisances arising from dust, noise, odors and slipperiness. While it is generally conceded that the best, most durable and latterly the most economical type of pavement to lay on steep grades of business streets is rough granite or whin block, its use is limited to such physical conditions on account of its noise and its roughness to automobiles and pleasure vehicles, and its destructive effects on horses' hoofs. Asphaltic mixture pavements, on the other hand, are noiseless, practically dustless, and afford easy and pleasant locomotion, but in wet and frosty weather many types of this pavement are slippery, particularly on average grades, and are therefore unsuitable for heavy teaming traffic.

Such instances emphasize the need for care and discretion in the selection of a class of pavement to be adopted in any city street—conditions which at best only require the exercise of commonsense judgment.

Width of Pavements.—This is an important feature of pavements, which is frequently lost sight of in designing city streets. Neglect of fundamental principles in the adjusting of the width of the pavement often gives rise to subsequent widening and reconstruction at heavy expense. Purely residential streets and business streets should be treated on their own merits and semi-residential streets destined to become business streets should have special consideration. Traffic conditions present and prospective should always be duly considered, as not infrequently an important street will subsequently be selected because of its preferable grades or location for a car line and unfrequented thoroughfares may become business streets owing to the location of works or factories, or railway and dock terminals. An excessively wide pavement on a residential street is an unnecessary and extravagant expense inasmuch as it is expensive to maintain and clean, while a narrow pavement on, say, a car line street is a source of danger and tends ultimately to congestion of traffic, and resultant financial loss to the travelling and business public. In residential streets primary attention should be paid to aesthetics; in business streets the study of traffic conditions should have first consideration.

Construction of Pavement.—Next in importance to the selection of type of pavement is its construction. The permanent value of any pavement, be it of the poorest type, depends to a very great extent on the discriminating selection of the materials which form the component parts of the pavement, and the care, efficiency and thoroughness used in the grading or mixing of materials, and in the actual laying down of the pavement. In paving, as in any other class of construction, the greatest stress should be laid on the studied and systematic attention to the all-important details, and the necessity for taking pains, as close, careful and scrutinizing inspection is necessary right from the drainage and preparation of the subgrade to the finishing touches on the wearing surface. Instances are known to us all of the best types of pavement turning out poor and unsatisfactory just because of carelessness in construction, or laxness and indifference in inspection, while many comparatively poor types of pavement often stand the test of time and traffic because materials and workmanship employed thereon were of the best procurable. For instance, bituminous pavements which appear to be best adapted for this climate have been laid under similar conditions, but have produced dissimilar results, chiefly due to defective materials and more defective construction. Again, wood block pavement, which has been so much condemned in this neighborhood, is one of the best pavements to be seen in most European cities and in Australia, because the blocks used and the methods of construction are entirely different to those in vogue in most American cities.

Brick, concrete, dolarway and the various asphaltic mixtures are the chief pavements upon which the attention of engineers has been concentrated of late. The adoption of the various types for highway construction obviously depends on the varying conditions and circumstances—the location and grades on which they are to be built, and the particular use to which they are likely to be put. A brief reference to each type of pavement may suffice to demonstrate their demerits and merits and their usefulness or otherwise, particularly as applied to main rural highways.

Brick.—The adoption of a brick pavement necessitates the use of an unyielding concrete foundation upon which their stability and durability so greatly depend. The high cost of a concrete foundation, particularly in districts where transportation facilities are not good, and the excessive cost of the bricks, renders this class of pavement heavy in first cost. The objects aimed at in their adoption are the furnishing of a double wearing surface, which will have the minimum of traction resistance and the maximum of wearing resistance. The cheaper ordinary brick, which figured so much in earlier construction, has now been supplanted by the more expensive vitrified brick. The principal advantages of brick pavement are:—

(1) The sure foothold they afford for horses.

(2) Their special adaptability to heavy grades.

(3) The comparatively little dust and mud which they yield.

(4) The ease and expedition with which they can be repaired.

(5) Their durability under moderate traffic.

The principal disadvantages are:—

(1) Their excessive first cost.

(2) The lack of uniformity in the quality of the bricks, some bricks being softer and more porous than others.

(3) The lack of evenness and regularity in the wearing surface.

(4) Their disagreeable noise under team traffic.

Finally, as laid on a rural highway, they appear to be out of all harmony with the remainder of the road and are, therefore, of little or no aesthetic value. However, with the perfecting of a more uniform and properly vitrified brick and the improvement in the modes of construction, there is little doubt that this form of pavement will shortly be more in general adoption on arterial highways.

Concrete.—Until quite recently the use of concrete in the construction of pavements was wholly confined to the foundation, but pavements entirely composed of concrete are now being more generally adopted, not only in city streets but also on rural highways. As in every type of composite pavement, their success depends upon the proper grading of the best procurable materials, and on the workmanship being of the highest order. The advantages claimed for such roadways are:—

(1) The low first cost. It is contended that they cost little more than the bare cost of the foundation used for other composite pavements.

(2) The pavement is a monolith, and therefore the wearing surface cannot separate from the foundation as in other composite pavements.

(3) The surface can be made rough or smooth as desired to meet different conditions.

(4) They require no subsequent coating of material to protect them from the wear and tear of traffic.

(5) They are impervious to injurious oils and gases which affect bituminous pavements in particular.

(6) They strengthen with age.

(7) As they contain no joints, no dirt can collect on the surface and they are therefore easily cleaned.

(8) All the materials are easily procurable.

(9) They are durable under ordinary traffic.

Against these qualifications are set the following disadvantages:—

(1) The noise produced under team traffic.

(2) The cracking and consequent disintegration due to their expansion and contraction under extremes of temperature.

(3) Their injurious effects on horses' hoofs.

(4) The difficulty of maintenance, it being hard to perfectly join up new concrete with old concrete which has been set for some time.

(5) It is not sufficiently resilient and elastic.

(6) Its rigidity is not calculated to withstand the constant blows of horses' hoofs or the heavy impact of motor trucks.

When, however, some of the above drawbacks have been overcome or minimized there is no doubt that concrete roads will be a more marked feature in highway construction in the near future. "Hassam" is a patent form of concrete pavement from which it differs principally in that the rock aggregate of the pavement is laid and rolled instead of being mixed along with the cement, etc., and the cement grout poured into the stone until the voids are filled. When confined to streets with light traffic, where there is no vibrating and impounding action of street cars, etc., it appears to give fairly satisfactory results, but unfortunately it has been laid on business streets of which he subgrade is chiefly composed of "made" ground and therefore has been unable to withstand the heavy compressive, as well as tensile, stresses to which it has consequently been subjected.

Dolarway.—As in other matters, so in pavement. Necessity has been the mother of invention. Dolarway was invented or the idea conceived of applying a thin layer of liquid bitumen to a concrete surface, and sprinkling coarse sand thereon. Such a precaution is alleged to reduce the contraction and expansion common in ordinary types of concrete pavement, by protecting it from the alternating influences of temperature. This so-called wearing surface also reduces the noise, presents a better and more beautiful appearance, saves the horses' hoofs and tends to add to the life of the pavement. The effective results of such treatment are, however, very questionable, the bituminous layer being too thin to afford the necessary elastic, resilient and durable surface, particularly on streets with heavy mixed traffic.

Asphaltic Mixture Pavements.—Under this head are included "bitulithic," "asphaltic concrete" and "sheet asphalt." The latter pavement, not being generally adaptable for rural highways, need not be discussed.

Bitulithic and asphaltic concrete pavements can be laid either on a concrete base or a rock base, the typical bitulithic being chiefly laid on the rock base. The composite parts of the wearing surface of both pavements are very similar, being stone, sand and bitumen. But they are dissimilar in that the sizes of the stone used and the grading of the stone vary greatly. In the case of bitulithic the crushed stone is carefully graded in predetermined proportions, scientifically and mechanically mixed in special paving plants, and the mixture spread on the rock or concrete foundation and carefully rolled to afford a compact wearing and waterproof surface. Asphaltic concrete is similarly prepared with different sizes of crushed stone and similarly applied to the foundation. Although the results produced are not quite alike, the objects aimed at in both classes of pavement are closely akin, and while the typical bitulithic pavements have been in longer use than the generality of asphaltic concrete pavements, the latter are becoming more popular and acceptable because they are unpatented and are, therefore, cheaper in first cost. Now that portable or semi-portable paving plants are in vogue, the use of such pavements has been generally extended to the construction of bituminous concrete roads in rural districts. As such pavements approach nearest to the theoretical and practical conception of a first-class pavement and are particularly adapted to country highways, they are destined to be more adopted than brick, concrete or dolarway pavements. Such bituminous pavements appear to meet the urgent demand for special highway construction, not excessive in first cost, of great durability, and of pleasing appearance, made imperative by the general adoption of automobile and motor truck traffic. As they have met with very favorable results when laid on a rock foundation, an existing macadam road which has proved to be no longer serviceable for the traffic it has to withstand can be readily and easily transformed into a fairly permanent paved highway at comparatively less cost than other types of pavement laid on a concrete foundation. The modus operandi in converting a macadam road into a paved highway chiefly consists in scarifying the existing roadbed, to reduce the crown and afford a bond for laying of additional medium sized rock. The new foundation thus created is consolidated by careful rolling and coated with bituminous paint, upon which is applied usually a 2-inch wearing surface as mixed in the paving plant. Provided always that the materials, mixing and workmanship are all equally good, asphaltic mixture pavements are claimed to be the best adapted for general city work and for use on rural highways. While the perfect pavement to suit all conditions and circumstances has not yet been devised, bituminous pavements approach nearest to the theoretical and practical type of pavement, inasmuch as all the ingredients used therein are natural mineral products, to the grading and mixing of which all the available skill of the laboratory has been applied. Briefly, such pavements possess the following advantages: Durability, resiliency, elasticity, noiselessness and dustlessness. They have a good appearance, are sanitary and can be easily cleaned. In most circumstances they afford good foothold for horses. As regards cost, they are cheaper than most pavements and, taking the cost of maintenance into account, they are cheaper than almost any type of pavement.

The American Society of Municipal Improvements will assemble in Wilmington, Delaware, October 7-10, 1913. The society has for its purpose the dissemination of information concerning municipal departments and municipal works construction and the promotion of improved methods in management.

The question of the disposal of refuse is dealt with in a vigorous and popular way in an illustrated pamphlet, now in course of publication by the Commission of Conservation. The commission is asking the co-operation of the medical health officers in the various towns and cities throughout the country in distributing this pamphlet, and it is hoped the demand for it will be as large as the importance of the subject merits. Pamphlets may be secured gratis by all bodies or persons interested, by applying to the secretary, Commission of Conservation, Ottawa, Ont.

ACTION OF VARIOUS SUBSTANCES ON MORTAR

By Richard K. Meade.

THE following results on the action of various substances on cement mortars were obtained from experiments begun some five or six years ago, and were undertaken to ascertain the action of alkaline waters on concrete, to find out if destructive action really did take place, and also to determine which of these salts ordinarily found in ground water were the cause of such disintegration. The report was published in the form of a paper presented before the convention of the American Society for Testing Materials, at Atlantic City, on June 26th.

The salts usually found in the so-called "alkali waters" of the West are also those which occur in sea-water and are those present in largest amounts in many spring and river waters. They are sodium chloride, magnesium sulphate, calcium sulphate, sodium sulphate and sodium carbonate. In order to test the effect of solutions of these substances on cement mortar, a sample of normal Lehigh Valley cement was selected and from it a large number of sand briquettes were made.

Analysis and tests of the cement are given in Table I.

Table I.—Analysis and Tests of the Cement Employed.

ANALYSIS

Silicia, per cent.	20.20
Oxide of iron, per cent.	2.50
Alumina, per cent.	6.96
Lime, per cent.	62.40
Magnesia, per cent.	3.01
Sulphur trioxide per cent.	1.60
Loss on ignition, per cent.	2.38

PHYSICAL TESTS

Soundness

Steam	O.K.	Cold water	O. K.
Boiling	O. K.	Air	O. K.

Fineness

Passing No. 100	94.3 per cent.
Passing No. 200	77.8 per cent.

Setting Time

Initial set	2 hr., 15 min.
Final set	6 hr., 30 min.

Tensile Strength, lb. per sq. in.

	Neat	Sand
1 day	315	...
7 days	765	245
28 days	875	340
3 months	885	415
6 months	885	435
1 year	890	510

All briquettes were made from a mixture of one part cement and three parts standard Ottawa sand. They were allowed to harden 28 days in air and then immersed in a solution of the salt. The briquettes were piled in such manner that the solution had access to almost their entire surface.

The solutions in all cases except that of the calcium sulphate, which was a saturated solution, were made up of one part of the salt to 100 parts of water, to form practically a 1-per cent. solution. At first the solutions were changed every few days, but after the first month the solutions were changed weekly and after the first year less often. The results obtained are given in Table II.

First it should be remembered that the 28-day strength of briquettes kept in air is much less than that of those kept in water. As will be seen from the results given in Table II., the sulphates have a marked action on concrete, which seems to be most apparent in the case of the magnesium salt. The action of magnesium sulphate on cement mortars has been discussed quite voluminously of late and I will not go into it to any length in this paper

Table II.—Action of Various Salts on Cement Mortars.

Age in Soution	Tensile Strength, lb. per sq. in., after immersion in Magnesium Sulphate	Magnesium Chloride	Calcium Sulphate	Sodium Sulphate	Sodium Chloride	Sodium Carbonate
0 days†	219	219	219	219	219	219
7 days	268	245	227	257	236	225
28 days	272	300	300	334	268	277
3 months	287	315	334	354	299	324
6 months	196	202	314	378	287	320
1 year	*..	115	209	271	310	337
2 years	...	*..	*...	141	325	360

* Disintegrated.

† The briquettes were aged 28 days in air before immersion.

beyond stating that we carefully analyzed the affected portion and the unaffected portion of a sand briquette which had been stored in a solution of magnesium sulphate. These analyses are given in Table III.

Table III.

	Before Immersion	Unaffected Portion	Affected Portion
Silica, per cent.	75.12	73.96	60.40
Oxide of iron, per cent.	0.52	0.60	0.30
Alumina, per cent.	1.15	1.30	0.64
Lime, per cent.	14.80	14.50	14.21
Magnesia, per cent.	0.70	1.66	3.64
Sulphur trioxide, per cent.	0.33	0.83	5.78
Loss on ignition, per cent.	7.02	7.14	14.97

The large increase in the magnesia and sulphur trioxide and the decrease on the oxides of iron and alumina indicate the elements which react with each other. The loss in silica may be due to chemical action also, but as the surface of the briquettes was very much attacked and the sand grains could be scraped away with the finger, I am inclined to think that the lower silica in the disintegrated portion was probably due to mechanical causes rather than chemical action. It will be noted that in almost all cases the first effect of the solution was to increase the strength of the briquettes and that signs of disintegration in no cases became evident until after a period of three months in the solution.

Some of the briquettes were even boiled in a 5-per cent. solution of magnesium sulphate for several days, and in all cases the briquettes were much stronger after boiling than they were before and fully as strong as briquettes boiled in pure water, showing how slow the action of the sulphates is.

The briquettes which failed were considerably swollen and presented much the appearance of a baked potato which has burst its jacket.

Various authorities have proposed at different times the use of divers ingredients in concrete exposed to sea-water, with a view to their reacting with the salts of the latter to form insoluble compounds which would protect the concrete. Most persistently suggested of these are the salts of barium, which form with soluble sulphates insoluble barium sulphate. I tried both barium chloride and barium carbonate. These were ground very finely and mixed with the cement. I employed 2 per cent. of barium chloride with the cement, and also 2 per cent. and 5 per cent. of barium carbonate. Sand briquettes were made from these mixtures and the test pieces stored in a magnesium sulphate solution containing 10 grams of the salt to the liter. The results are given in Table IV., and, as will be seen, none of these compounds arrest the destruction.

Table IV.—Action of Magnesium Sulphate on Cement Mortars Containing Barium Compounds.

Age in 1 per cent. Solution of Magnesium Sulphate	Strength, lb. per sq. in. of briquettes containing— 2 per cent. of Barium Chloride	2 per cent. of Barium Carbonate	5 per cent. of Barium Carbonate
0 days*......	181	115	166
7 days	...	221	257
28 days	213	246	346
3 months	306	311	346
6 months	265	204	274
1 year	146	Disintegrated	Disintegrated

* The briquettes were aged 14 days in air before immersion.

Some years ago an English chemist suggested the use of finely ground, burnt red brick as an admixture for concrete which was to be used in sea-water. After reading this paper it occurred to me that the resistance to sea-water claimed for high-iron cements might be due to the presence of oxide of iron in the cement. I therefore had sand briquettes made up containing oxide of iron in various forms and conditions, namely, red or ferric oxide, magnetic oxide of iron, venetian red (an impure oxide of iron made from low grade iron ores, so-called "paint ores" of the Lehigh district), and finely ground red brick, using of these 5 per cent. of the weight of the cement in each case and placing the briquettes in a 1-per cent. solution of the magnesium sulphate. The results are given in Table V. As will be seen, the additions of iron compounds are in no way beneficial to cements to be employed in sea-water.

Table V.—Action of Magnesium Sulphate on Cement Mortars Containing Iron Oxides, Etc.

Age in 1 per cent. Solution of Magnesium Sulphate	Tensile Strength, lb. per sq. in., of briquettes containing 5 per cent. of— Ferric Oxide	Magnetic Oxide	Venetian Red	Brick Dust
0 days*....	218	225	165	170
7 days	275	280	225	220
28 days	310	340	300	275
3 months ..	355	340	345	310
6 months ..	310	280	215	205
1 year	125	105	Disintegrated	Disintegrated

* The briquettes were aged 14 days in air before immersion.

I next tried waterproofing the mortar on the theory that if the circulation of water through the pores of the mortar could be stopped no chemical action could take place. I employed for this purpose both a high-calcium and a magnesium-hydrated lime, road oil (as recommended by Page), a mixture of silicate of soda solution and fish oil (a well-known waterproofing compound), and lime soap (the basis of many waterproofing compounds). I also tried dipping the briquettes first in a hot solution of soap and then in one of alum (Sylvester's Process). The results of the tests of sand briquettes made from these mixtures and stored in magnesium sulphate solution (10 grams to the liter) are given in Table VI.

Table VI.—Action of Magnesium Sulphate Solution on So-Called Waterproofed Mortars.

Age in 1 per cent. Solution of Magnesium Sulphate	Tensile Strength, lb. per sq. in., of briquettes containing— 15 per cent. of Hydrated Lime (Calcium)	15 per cent. of Hydrated Lime (Magnesian)	10 per cent. of Road Oil	2 per cent. of Lime Soap	2 per cent. of of Oil Silicate Soda	Treated with Alum and Soap
0 days* ..	215	215	165	185	160	220
7 days ..	215	225	200	210	200	235
8 days ..	315	320	210	250	245	275
23 months .	245	260	260	275	260	265
6 months .	200	245	210	230	225	215
1 year ..	120	105	140	180	165	185

* The briquettes were aged 14 days in air before immersion.

It will be noted that, while the disintegration is evidently taking place in these test pieces, all of these compounds seem to arrest it to some extent at any rate, and in the case of the lime soap and Sylvester Process this is quite marked.

I also investigated the action of magnesium-sulphate solution on cements high in silica. For this purpose samples of commercial cement, one high in silica and low in alumina and one low in silica and high in alumina, were selected; sand briquettes were made of these and immersed in a solution of magnesium sulphate containing 20 grams to the liter, or practically a 2-per cent. solution. The cements selected had the following analysis:—

	Low-Alumina Cement	High-Alumina Cement
Silica, per cent.	23.24	19.86
Iron Oxide, per cent.	2.25	2.56
Alumina, per cent.	5.03	7.60
Lime, per cent.	63.55	63.12
Magnesia, per cent.	3.05	3.10
Sulphur trioxide, per cent.	1.51	1.66

As will be seen from Table VII., the low-alumina cement resists the action of magnesium sulphate much better than the high-alumina one.

Table VII.—Action of Magnesium Sulphate Solution on High and Low-Alumina Cements.

Age in 2 per cent. Solution of Magnesium Sulphate	Tensile Strength lb. per sq. in., of High-Alumina Cement	Low-Alumina Cement
0 days*	242	225
7 days	318	307
28 days	404	430
3 months	402	476
6 months	230	472
1 year	Disintegrated	500
2 years	...	425

* The briquettes were aged 14 days in air before immersion.

In the above experiments, both cements were commercial cements; but the high-alumina cement when received was not quite so finely ground as the other one, so it was ground to practically the same degree of fineness in a small jar mill (or to 86.2 per cent. passing the No. 200 sieve), so that the fineness of the two samples might in no way influence the results. Both these sements were made from cement rock and limestone.

In connection with the use of concrete for mine props, where it is often exposed to the action of dilute solutions of sulphuric acid, the following experiment was tried. Sand briquettes were allowed to harden 28 days and then were placed in a solution containing 250 grains of sulphuric acid (H_2SO_4) to the gallon. The solution was changed frequently and the briquettes broken at regular intervals. The disintegration of concrete by such acid water is shown by the following:—

Age in Solution	0 days	7 days	28 days	3 mos.	6 mos.	1 year
Tensile Strength, lb.	226	299	300	280	176	Disintegrated

Several years ago the question of the action of oil on concrete was brought up at one of the meetings of this society in connection with a paper by Professor Carpenter. In his experiments, oil was mixed with the concrete. In the discussion which followed the reading of the paper, a number of gentlemen suggested that what was needed most was information relative to the action of oil on concrete which had already hardened, in view of the employment of concrete for machinery bearings, engine room and factory floors, etc., where it is subjected after being fully hardened to the oil which leaks from the bearings of the machinery. I went home from this meeting and had a number of sand briquettes made and allowed them to harden two weeks in air. These were stored in air, in engine oil, in cylinder oil, and in black oil, and broken at stated periods. The results are given in Table VIII.

It will be noted that the engine oil and the cylinder oil have practically no effect upon concrete. One would think that as the latter has a considerable proportion of animal oil in its composition it would be apt to appreciably affect concrete exposed to it. On the other hand, the action of the black oil seems strange in view of the

Table VIII.—Action of Lubricating Oils on Concrete.

	Tensile Strength, lb. per sq. in., of briquettes kept in			
Age in Oil	Air	Engine Oil	Cylinder Oil	Black Oil
7 days*	218	252	235	234
28 days	233	240	273	222
3 months	287	251	221	181
6 months	303	232	209	131
1 year	293	231	203	Broke in clips

* The briquettes were aged 14 days in air before immersion.

fact that it is a straight mineral product. All of these briquettes had absorbed considerable oil, the actual gain in weight of each set at the end of the year being as follows:—

In engine oil	10.6 per cent.
In cylinder oil	10.0 per cent.
In black oil	12.0 per cent.

The briquettes in the black oil had not swollen perceptibly and seemed merely to be weak.

The experiments given above were all made upon very small test pieces and hence the action of the solutions upon them were much more rapid than they would be upon a large mass of concrete.

The paper was followed by lengthy discussion, Dr. Allerton S. Cushman, of the Institute on Industrial Research, Washington, stating that his experiments largely corroborated those of Mr. Meade. As a probable cause for the disintegration of concrete in alkali waters, discussion tending to show that chemical changes cause undue expansion, and that the best protective methods of preserving concrete where used in localities having black alkali waters, as is the case in many parts of the west, were by the use of coal tar oil. Experiments have also shown that briquettes tempered with copperas have never shown signs of rupture nor have they cracked when submerged in alkali water, and that after having been submerged in this water, they get very hard. Others have shown that concrete in waters carrying sulphates almost invariably change the calcium hydroxide to calcium sulphate, and that this chemical change, demanding more room for increased expansion, disrupts the concrete, and in but a comparatively short time causes disintegration. Tests also showed that in using black oils for waterproofing, trouble might be caused and disintegration follow if the oil used contained even a trace of sulphuric acid. The author of the paper stated that the oil used in the tests as referred to in his paper was a residual oil as used only for the lubrication of very heavy machinery, and that the very slight flaking or sloughing off was on the surface of the foundation only, and did not continue into the concrete, although considerable oil was absorbed by these foundations.

Reference was made then to a method of waterproofing cement used in construction in sea-water. This method is credited to Arthur Rea, of France, and consists of adding a small percentage of gypsum, say, 5 to 20 per cent., to accelerate action, and to add to the concrete finely crushed marble. So far as is known, this method has proven very satisfactory in that country, although experiments made along these lines in Boston harbor, using six representative brands of cement, showed various results with these different cements. At the end of six months all briquettes tested had been slightly reduced with the exception of those made of one brand of cement. In adding waterproofing materials, it was stated in this discussion that the action of a solution of some salts, if added while plastic, will cause the concrete to expand unusually, while one or two others may show no such effect, but when added after the concrete has set, some of these solutions may cause the concrete to disintegrate. Many cases are in existence where concrete in sea-water along the Atlantic coast shows clean sharp edges after having been subject to this water for five years.

AMOUNT OF CEMENT FOR CONCRETE.

Mr. Stanley Macomber, city engineer of Centralia, Wash., in an article in the the Iowa "Engineer," states that a number of engineers in Washington are using clauses similar to the following in connection with their specifications for concrete work:—

Every cubic yard of concrete 1:3:6 mixture shall contain at least 4 sacks of cement.

Every cubic yard of concrete 1:3:5 mixture shall contain at least 4½ sacks of cement.

Every cubic yard of concrete 1:1:1 mixture shall contain at least 12 sacks of cement.

Every 2 cu. ft. of top mixture 1:2 shall contain at least 1 sack of cement.

For cement over this amount nothing will be paid the contractor.

For every sack of cement under the above amount the regular price shall be deducted from the total sum due to the contractor.

The contractor to figure on the above amounts rather than on the direct mixture.

Arrangements must be made with the city engineer for the proper inspection of the amount of cement used.

It is also stated that during the day the inspector tries to keep the mix as near correct as possible, and at night the empty cement sacks are counted and a material slip filled out, signed by the inspector and the contractor. A copy is given the contractor and a copy put on the file in the office. When it comes to final settlement these slips are taken as receipts for the amount of cement used. The amount of cement hauled on to a job is also kept in this manner as a check.

The area and mileage of street paving of various classes in the city of Philadelphia is given as follows in the annual report of the Bureau of Highways, of which Wm. H. Connell is chief:—

Character.	Sq. yards.	Miles.
Granite block	6,653,532	352.99
Asphalt (sheet)	6,959,656	472.35
Asphalt (block)	72,532	7.49
Vitrified brick	2,376,224	163.63
Cobble	162,775	14.02
Rubble	93,182	6.69
Slag block	78,071	8.13
Cement and granolithic	54,242	11.03
Wood block	121,505	4.06
Totals	16,571,719	1,040.39
Bituminous macadam roads	312,104	29.01
Waterbound macadam roads	3,035,429	261.31
Total macadam roads	3,347,533	290.32
Grand total (improved pavements and macadam roads)	19,919,252	1,330.71
Earth roads	....	179.06

THE DESIGN OF CENTRAL HEATING SYSTEMS

PART II

THE PRODUCTION OF HEAT THE OBJECTIVE TO BE KEPT IN MIND—TYPES OF MACHINERY—TUNNELS, PIPING SYSTEMS, AND OTHER ACCESSORIES.

By A. G. CHRISTIE, M.E.,
Assistant Professor of Steam Engineering, University of Wisconsin.

THE **Design of the Heating Station.**—The central heating plant should be so designed that the production of heat is its prime objective. The heat, however, may be developed with high pressure on the boilers, and this pressure may be reduced by passing a portion or all of the steam through engines. A portion of the heat is thus converted into work, and may be utilized to drive electric generators. Any further heat demand may be met by passing high-pressure steam through a suitable reducing valve. In other words, the station should be so designed that heat is the main output and electricity a by-product. This condition is secured when the demand for steam by the engines driving the generators is entirely submerged by the average demand for heat during a greater portion of the heating season. It is possible with this arrangement to select boilers of capacity proportional to the heating loads, and to keep in service the proper number of boilers to most economically meet the demands for heat, which will vary almost directly with the outside temperature. There are, then, no extreme peak loads during the day in the boiler-room, and consequently no fires are kept banked between peaks.

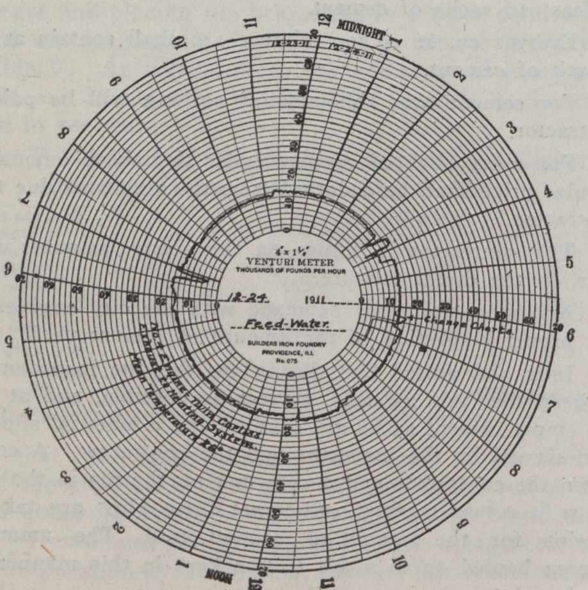


Fig. 1.

Fig. 1 shows a typical chart from the Venturi meter on the boiler feed-line of the Capitol Heating Plant at Madison, Wis., where the steam demanded by the power load shown on Fig. 2 is entirely submerged by the heating load, which, as the chart shows, is uniform for the twenty-four hours.

When a plant is run primarily for generating electricity and the exhaust steam is a by-product and required to the amount represented by the average load on the plant, there will be peak loads at certain times of the day, and at such times exhaust steam will be wasted. Boilers must be kept with banked fires to meet these peak demands for steam, and, on account of these stand-by losses, operation must necessarily be less efficient than when the steam demand for heat predominates, and, owing to the nature of the service, is practically uniform.

Many of the older heating systems were installed with the idea of using exhaust steam as a by-product and with no real value. In consequence, they have been financial failures on account of inefficient plant operation. In some other cases the overhead plant charges were not equitably distributed between the electric services and the heating system, resulting in ridiculously low heating rates.

Several utilities which supply cities with hydro-electric power find it necessary to maintain auxiliary steam plants in the city, especially when the power has to be transmitted for some distance from its point of generation. Frequently fires are banked under the boilers of these auxiliary plants at all times for either emergency or peak-load service. Under such conditions a heating system should prove a valuable addition to such service, not only from an operating, but also from a financial standpoint.

It can thus be seen that there is considerable justification for the assertion that the heating plant must be primarily for heat and not for power. This fact is now recognized by all leading heat engineers, as instanced by an abstract from a recent address of Mr. C. R. Bishop, in which he states: "To secure maximum results, the demand for steam for heating should be slightly in excess of the ***maximum amount*** of exhaust steam available at all times."

The detail design of every central station presents a new set of problems, so that no specific rules of design can be laid down. The size of the plant is dependent on the extent of the proposed service. The character of the units to be installed is determined by the fuel cost at the plant. If coal is cheap, it would not be profitable to install expensive equipment. But where coal is dear, consideration should then be given to the most efficient equipment that is on the market, and additional special apparatus may be installed to secure economical operation. It is, therefore, advisable to determine as closely as possible the probable future cost of coal before the designs are made, and to be guided thereby in the selection of equipment. When purchasing engine equipment for a central station, those types or combination of types should be selected which will serve throughout the whole year, and will, therefore, not involve overhead charges with no returns during the summer season.

The plan of the station should always provide for future extensions when such are contemplated. A usual arrangement is to place the engine and boiler-rooms side by side, and with the backs of the boilers towards the brick wall separating the two rooms. The engines may be placed on a higher level than the boilers, and the basement below the engine-room will serve as a pump and heater room, and also as a distributing centre for the heating system.

When a heating station is located in a district where real estate is extremely high, it may be desirable to make the plant double-decked, i.e., the engines are placed on a second floor directly above the boiler-room. This construction is feasible when steam turbines are used. However, when these engines are run condensing, this arrangement is not desirable, as it is not economical to raise water for cooling purposes to such a height. This objection does not hold when the units generally operate non-condensing.

A large storage of coal, either in bunkers or exterior to the power plant, is absolutely essential to guarantee a supply of heat in case of such emergencies as strikes on the railroads or in the mines, or freight blockades cutting off the coal supply. Except at the lake ports, all Wisconsin's coal supply comes from Illinois, and is hence subject to blockades and snow troubles. When land is dear, coal bunkers for storage should be built in the plant itself, in which case coal-conveying machinery must of necessity be installed. In other cases, the size of the plant and the cost of labor will be factors in deciding the advisability of installing coal and ash-handling systems. Regarding the disposal of ashes, many utilities have found that building contractors and others will remove all well-burned ash and clinker for use in concrete construction and for filling in.

When the plant contains only a few boilers of small size, hand-fired furnaces will give the best economy, provided these furnaces are properly designed and are handled intelligently. Furnaces of the Dutch oven type or with overhead brick arches should have a preference, as they aid materially in reducing the smoke nuisance.

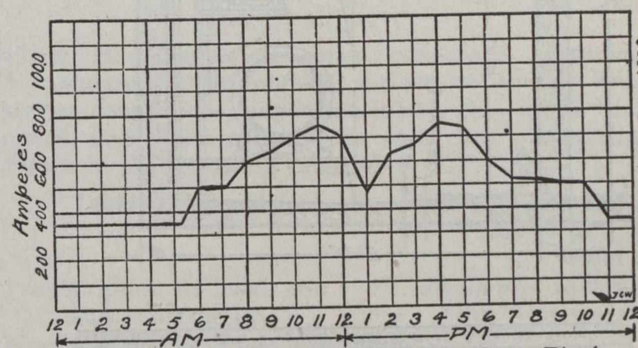
The cost of labor is paramount when considering the question of hand-fired furnaces or mechanical stokers. In general, one fireman can attend to coal, water and ashes on 300 horse-power of boilers in a hand-fired plant. With automatic stokers, overhead bunkers and down-spouts, one fireman can easily take care of 2,000 horse-power, or even 3,000 horse-power, depending on the size of the boilers, and at the same time maintain a high and uniform degree of efficiency. It will generally be found economical to install stokers where three or more boilers of 300 horse-power or over are continuously in service, especially when screenings or slack are burned.

By abstracting part of the waste heat from the flue gases from the boilers economizers aid in the further recovery of the heat generated in the furnace. Such apparatus is sometimes desirable where coal is expensive. The scale-forming properties of the water used in the economizer will determine to a large extent the expense involved in cleaning. In hot water systems the water is frequently circulated through an economizer before being pumped back into the system. By cooling down the flue gases, the draft on the boilers is reduced by economizers when chimney draft only is used. Hence, a higher and more expensive chimney or a mechanical draft apparatus must be employed. Some engineers prefer to install more heating surface in their boilers than to use economizers. At best, economizers are expensive and require considerable care to be kept in good working order.

The piping system of a heating station cannot be specified by any set of general rules. However, all such piping should be in simple systems, and valves should be easily accessible at all times. Engineers should insist on high-grade pipework throughout the plant.

It is always advisable in plants of sufficient size to warrant the expense to install Venturi meters on the boiler feed-line of a steam plant or on the delivery line of a hot water plant. This enables reliable records to be kept of the heat output of the plant and provides a means for checking the efficiency of the heating system.

The selection of prime movers for generating electricity will be influenced by the nature of the electrical service, the amount of the heat demand and the first cost of equipment. If it is desired to keep the electrical load submerged in the heating load at all times, and if the demand for steam for such service is almost equal to that of the heating system, then it will pay to put in the most economical engines obtainable in order to get the best results from the steam available. High-priced single or compound engines of the Corliss or four-valve type would be installed. If vertical compound engines of the high-speed English types were available, these would deserve consideration, both with respect to low first cost and high efficiency. In some plants compound condensing engines are installed which can run



Typical Daily Load Curve Capitol Power Plant.
December 1911.

Fig. 2.

during the heating season either as simple engines, or a quantity of steam can be withdrawn from the receiver for heating. During the summer season such engines are run condensing. However, in view of recent developments in low-pressure steam turbines, it would seem more advisable and less expensive to install such units to utilize the excess exhaust steam over heating requirements during peak loads on warm winter days and in summer.

Many improvements have been made on non-condensing steam turbines in recent years, so that these should be given careful consideration in selecting plant equipment. Bleeder types of turbines, which provide for the extraction of a portion or all of the steam after it has passed through the first stage, have become standard for heating purposes and are now being installed quite generally instead of steam engines. Steam turbines are adapted to the design of heating stations on account of their low first cost, small weight and cheap foundations. As there is no internal lubrication, oil troubles are avoided in the exhaust heating systems.

A 750 K.W. 60-cycle non-condensing steam turbine operating at 150 pounds pressure and 5 pounds back pressure above atmosphere will have a steam consumption of about 40 pounds per K.W.H. A 1,000 K.W. 60-cycle machine will have about 1 pound per K.W. better water rate at full load. On both of these machines the steam consumption at half load will be about 2 pounds per K.W.H. higher than at full load. A standard 750 K.W. condensing turbine will have a steam consumption at full load of about 19.5 pounds per K.W.H., and at half load of about 22.5 pounds. The 100 K.W. condensing turbine would have a steam consumption of about 19.0 pounds per K.W.H. at full load and 21.0 pounds at half load.

If these condensing turbines are provided with automatic bleeding devices to take steam for the heating system at 5 pounds pressure above atmosphere, it will be possible with 150 pounds steam pressure and 28 inches vacuum to extract a maximum of 15,000 pounds of steam per hour from the 750 K.W. turbine at half load, with a total flow of steam at the throttle of about 16,000 pounds. At full load the maximum extraction would be about 28,000 pounds with a total flow at the throttle of about 29,000 pounds. The 1,000 K.W. condensing turbine under similar conditions will have a maximum bleeding capacity of about 19,000 pounds per hour at half load, with a total flow at the throttle of 20,000 pounds. At full load it is possible to withdraw 37,000 pounds per hour with a total flow at the throttle of 38,000 pounds.

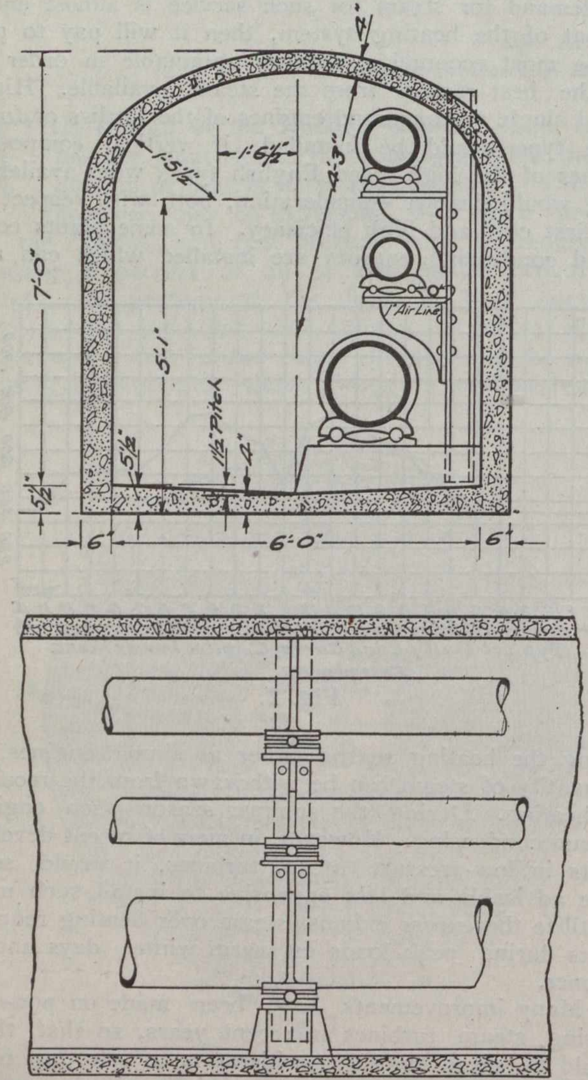


Fig. 3.—University of Wisconsin—Standard Heating Tunnel.

This data, from a leading manufacturer, is presented to show the results that can be expected from such type of turbine. The advantage of the bleeder type lies in the fact that it may be operated condensing entirely during the summer months, and thus high efficiency may be maintained.

There has been considerable information published relative to the bleeder type of turbine. Further data on this question can be found in a paper by A. H. Kreusi on "Heating in Connection with Steam Turbines," read before the National District Heating Association at Detroit in June, 1912, and also a paper by E. D. Dreyfus on "Notes on an Economic Survey of Combined Central Heating and Electric Plants," presented at the same meeting. The latter paper presents some interesting graphical diagrams showing the results obtained with Westinghouse bleeder turbines.

In many plants it has been found more desirable to install separate condensing units than to attempt to adapt one type of engines to all conditions of operation. These condensing units can be used on the peak loads. Occasionally storage batteries are also provided to improve the load factor by helping out on peaks.

The boiler feed-pumps in a large central station should be of the turbine driven type, although in small plants duplex steam pumps with automatic governors are generally used.

The circulating pumps in hot water heating systems are now generally of the centrifugal type, driven by non-condensing steam turbines, which exhaust into the heaters. Sometimes these pumps are motor driven, though this is not common.

Pipe Lines and Conduits.—The most important portion of the district heating equipment is the underground transmission system. For economy in operation this should be made of the very best possible construction, and should be easily accessible for repairs at all times. On the other hand, too high first cost results in high fixed charges on the service rendered. The conduits, pipe lines and auxiliary service must be designed so as to provide the most economical system in operation that can be installed with the capital available.

The franchise or permit of the heating company allows it to make use of the streets and alleys of the city. The plan of the city will show at a glance whether it is possible to use the alleys for conduits. The choice between streets and alleys depends on two things: (1) The relative cost of street and alley construction; and (2) the location of the buildings to be served relative to the streets or alleys. It has been authoritatively stated that, other things being equal, alley construction will cost 15 to 30 per cent. more for labor than street work, owing to the difficulty of working in the narrow space. An important factor affecting street construction costs is the amount of paving that has to be torn up and relaid. The heating companies are obliged in most cities to bring their service pipes to the curb line in a street and to the property line in an alley. This item of expense should not be overlooked in choosing between street and alley construction, for on wide streets the extra cost for service lines will more than eat up the saving in labor effected by street construction.

The form of conduit to be employed in any given installation will be dependent on local considerations. When a large main or a number of pipes, such as high-pressure steam, low-pressure steam, condensation return or other piping must be laid for some distance in one direction before branching off for distribution, it is probable that a reinforced concrete tunnel would be most satisfactory. However, it will generally be found that the greater portion of all heating systems are laid in some form of underground conduit.

Piping tunnels allow joints to be watched and repairs and alterations to be made with comparative ease. Their first cost is high, but they never need opening up f properly built. Fig. 3 shows a section of standard piping tunnel used at the University of Wisconsin. The pipes are carried by saddles with ball bearings resting on brackets fastened to vertical I-beams, which are imbedded in the concrete. Any section of pipe can be readily removed with this construction. Anchors and expansion joints are provided at proper intervals. Tunnels need to be well underdrained, and should be provided with air-tight manholes at proper intervals. The radiation losses from piping in tunnels can be reduced to comparatively small amounts if covered to a sufficient depth with first-class moulded insulation materials.

If the distribution mains are too large for the service connected up, the per cent. loss will be unreasonably large, while if the capacity is increased to its ultimate limit, the line losses will become a very small percentage of the heat transmitted. Thus a line designed for 200,000 square feet of radiation will show a line loss of 10 to 20% of the heat supplied when only 50% of the service is connected. But when the whole ultimate load is applied the loss would become only about 4%. The normal condensation from radiation should then not exceed 0.05 pound per square foot per hour.

The requisites for good construction and efficient operation of pipe conduits are as follows:—

1. Drainage must be provided to remove all water accumulations from possible contact with pipe lines.

2. There must be adequate provision for expansion.

3. Drips and traps must be provided at intervals to remove condensation from radiation.

4. The pipe insulation must be efficient.

5. The conduit itself must be of good mechanical construction.

Drainage must be provided to keep both conduit and insulating materials dry at all times. This drainage is usually secured by first laying a tile drain in the bottom of the trench. Then a layer of coarse crushed stone is laid above and around this tile. The conduit can now be placed so that there is a filling of crushed stone on either side of it as high as its top. This enables the water percolating through the soil above to find an easier path to the drain than through the conduit itself.

Expansion joints must be provided at frequent intervals along the mains to take up the expansion and contraction from changes in temperature. A form of expansion joint which can be packed under pressure is shown in Fig. 4. This was designed by Mr. J. C. White, and has been in use for several years with entire satisfaction on both the Wisconsin State Capitol heating system and the University of Wisconsin heating system. The main body of this expansion joint is of cast-iron, and is bored out for the stuffing-box and threaded to receive the retainer ring as shown. The telescoping or slip section of pipe is made of tobin bronze, turned up and polished on the outside. The four packing rings, marked "a," and the two clamp rings, "b," are also of tobin bronze, and are all split in a similar manner to piston rings. The bull ring "c" has four holes at right angles to each other which connect the inside annular space with the outer annular ring, which in turn connects to the ¾-inch blow-off pipe on the lower side of the cast-iron body. The retainer ring "d" is of cast-iron, and is screwed in place by a special socket wrench. The packing may be of any "soft" variety, and can be withdrawn at will with steam on the line by simply opening the blow-off valve to the atmosphere. It is surprising how little steam leaks past the packing-rings even when the blow-off valve is open. This joint has been equally as satisfactory on high-pressure lines as on low-pressure. This form of expansion joint has proven the most satisfactory of any using soft packing. Goose-neck bends have been used occasionally, but are not suitable for conduit work.

There are several forms of expansion joints giving satisfactory service on low-pressure lines, and which employ copper diaphragms to take up the expansion and contraction of the piping. They are placed usually about 100 feet apart, with anchors midway between. A service outlet to customers is generally provided at the top of the cast-iron body of these expansion devices, and also at the anchor, fitting so that dry steam only passes out of the main.

Manholes must be provided above these joints, and also above any valves or other equipment that may need adjustment or inspection. However, manholes are a source of great heat loss, and hence as few should be used as is consistent with efficient operation of the lines.

The radiation loss from piping is dependent largely on the character of its insulation, the depth underground that the piping is placed, and, as already pointed out, the dryness of the conduit and its insulating material. Some insulating materials deteriorate with age. Gifford, in his book on "Central Station Heating," gives the following formula for finding this radiation loss:—

$$H = A \times C$$

where H = pounds of steam condensed by radiation, A = square feet of outside surface of piping, fittings, service connections, expansion joints, etc., in the heating mains, and C = a constant for each class of covering as shown in the following table:—

Table 3.—Coefficients for Radiation Losses.

Description of insulation and construction.	Value of C* steam at 5 lbs.	Value of C* water at average temperature.
Hemlock lumber, three 2-in. thicknesses, paper and shavings 1st year	0.03	0.02
Same .... 3rd "	0.05	0.03
Same .... 5th "	0.08	0.06
Same .... 8th "	0.10	0.07
Hemlock lumber, two 2-in. thicknesses or three 1-in. thicknesses, no paper or shavings... 1st year	0.05	0.03
Same .... 3rd "	0.07	0.05
Same .... 5th "	0.09	0.06
Same .... 8th "	0.10	0.07
4-in. segmental wood log, tin-lined, well under-drained—first year and as long as in good condition....	0.04	0.025
4-in. concrete conduit, 1-in. covering	0.08	0.06
4-in. concrete conduit, 1½-in. covering	0.05	0.03
4-in. concrete conduit, 2-in. covering	0.04	0.025
4-in. brick conduit, 1-in. covering.	0.08	0.06
4-in. brick conduit, 1½-in. covering	0.05	0.03
4-in. brick conduit, 2-in. covering.	0.04	0.025
4-in. partition tile conduit, 1-in. covering	0.07	0.055
4-in. partition tile conduit, 1½-in. covering	0.04	0.025
4-in. partition tile conduit, 2-in. covering	0.034	0.02
Two 1-in. thicknesses lumber with 3-in. concrete envelope	0.05	0.03
Tunnel construction 2-in. covering	0.045	0.03

*Values of C are given in pounds of steam. Multiply these values by 1,000 to get the approximate heat units.

It is very difficult to obtain any figures of actual tests or other records showing line losses in actual plants.

Mr. C. R. Bishop, of the American District Steam Company, states that with their standard wood-log construction the transmission loss of a low pressure steam system averages about 0.044 pounds of steam per hour per square foot of surface of underground mains, to which must be added a small percentage to equal unaccounted-for steam due to meter inaccuracies, leaky air vents, etc. Gifford, in his book on "Central Station Heating," states that the radiation loss in a steam system equals 0.05 pounds of steam per hour per square foot of underground main. The superintendent of one of the largest heating systems in Illinois, in a personal communication, stated that the loss in their mains is equal to 6% of the total steam leaving the station. This system includes 1,800 feet of 18-inch main installed in a brick tunnel and covered with a 2-inch covering of asbestos sponge felt, the remainder of the system has wood-log conduits.

The materials used for insulation will be discussed later in connection with conduit construction.

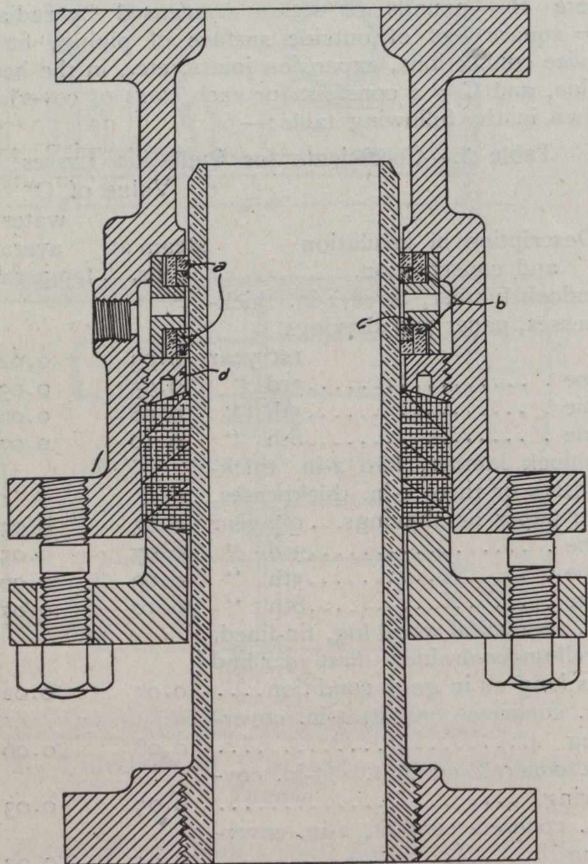


Fig. 4.—White's Expansion Joint.

The question of materials for pipe lines is naturally one of considerable importance. The American District Steam Company, who have probably had more experience with heating systems than any other concern in this country, have always maintained that strictly wrought iron pipe with long recessed couplings was far more durable than steel pipe. However, recent tests on steel pipe tend to show that there is not so much difference between the two classes of pipe as is claimed. Besides, it has become almost impossible to procure strictly wrought iron pipe except at prohibitive prices.

The proper size of the pipe lines to be installed is determined by their ultimate capacity and by the allowable drop on the lines. This will be determined with exhaust steam by the back pressure which can economically be permitted on the engine or turbine. With hot water, the designer must select such a pipe size that the sum of the losses in pumping due to friction, and in radiation, is a minimum. These calculations must be based in each case on the ultimate capacity of the pipe line.

The friction losses in heating mains must be carefully calculated before the final sizes are selected. A compromise has usually to be effected between the piping system with the least friction drop and that with the least heat losses. In general, however, the system must be so designed that a pressure of at least one pound above atmosphere must be maintained at the radiators at the extreme end of the system without requiring at the station too high a back pressure in the case of low pressure steam or too high a head to pump against in the case of hot water.

The allowable pressure drop depends largely on the pressure that is to be maintained at the station end of the system. For instance, the friction loss with 10 pounds pressure could be about double that of a system with 5 pounds pressure at the plant. There is a considerable mass of data on hand for calculating the sizes of steam mains for known pressure drops, but much of this is of a conflicting nature. For instance, Mr. C. R. Bishop states that in designing large low pressure steam systems with a maximum initial pressure of 5 pounds above atmosphere, the friction loss should not exceed one-quarter pound per square inch per 1,000 lineal feet of main. Gifford, in "Central Station Heating," gives sets of curves for allowable pressure drops for both hot water and steam. Values taken from these curves are very much in excess of those quoted by Bishop, and it would seem, therefore, that they are not very applicable to large heating systems.

Professor H. V. Carpenter gives a series of curves for the flow of steam through pipes in Power, December 17, 1912, but these curves are principally applicable to high pressure mains, as the lowest pressure drops plotted are one pound per square inch per 1,000 lineal feet of main. These diagrams, however, could be easily replotted for use on low pressure steam work. They are based on the formula of Unwin, which was confirmed later by tests made by Professor R. C. Carpenter and G. H. Babcock, and are probably correct enough for ordinary conditions.

$$W = 87.5 \sqrt{\frac{PYd^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

$$\text{or } P = 0.0001306 \frac{W^2 L\left(1 + \frac{3.6}{d}\right)}{Y d^5}$$

where W = weight of steam delivered in pounds per minute
P = drop in pressure in length L
L = lineal feet of pipe
d = diameter of pipe in inches
Y = mean density of the steam in the length of pipe under consideration in pounds per cubic foot.

Mr. Konrad Meier, in his book "Mechanics of Heating and Ventilating," reviews the various formulas proposed for the loss in pressure from friction on the flow of steam through pipes, and deduced the following formula for low pressure steam:—

$$P_f = 0.0257\ Y \frac{v^{1.97}}{d^{1.16}}$$

where P_f = pressure drop per foot of pipe
Y = mean density of the steam
v = velocity of the steam in feet per second
d = diameter of pipe in inches.

These exponents apply to steam at pressures slightly above atmosphere. The author also presents charts for use in solving these equations, but the values apply more directly to isolated plant construction than to central station mains.

The friction loss in hot water mains can be approximated closely by applying the well-known formula of hydraulics

$$h_f = \frac{a L}{D} \cdot \frac{v^2}{2 g}$$

where h_f = feet of head lost in friction, a = friction factor which, for wrought iron or steel piping, may be taken as equal to 0.02, L = length of pipe in feet, D = diameter of the pipe in feet, and $2g = 64.4$. This formula may be applied when all the water entering one end of the pipe passes out at the other. When the water is all taken off at intermediate tappings and the velocity at the extreme end is zero, the loss will be about one-third of this amount. For hot water systems in service the actual conditions lie somewhere between these extremes and so the actual loss must be assumed in the proportion to the amount drawn off. Hoffman, in his "Handbook for Heating and Ventilating Engineers," suggests using two-thirds of the value of h_f for hot water service mains with the usual customer's connections.

(To be continued.)

WATER WASTE PREVENTION IN NEW YORK CITY.

By I. M. De Varona,
Chief Engineer, Department of Water Supply, Gas and Electricity, New York City.

To avert the threatening danger of a serious shortage of supply for Manhattan and The Bronx in 1912, and, later, to avoid, if possible, the large expense attending the development of additional sources of supply for Brooklyn, which would otherwise have been required to adequately provide for the consumption in that borough until the Catskill water was available, the Department of Water Supply, Gas and Electricity of New York City instituted a vigorous campaign to reduce waste. This undertaking forms the basis of a paper read by Mr. I. M. De Varona at the recent American Waterworks Association convention at Minneapolis, of which paper this article forms a part. The intended purpose was fully and most satisfactorily accomplished in both the above-mentioned cases. The crisis of 1912, in Manhattan and The Bronx, was tided over, and Brooklyn may now safely await the introduction of the Catskill supply without further developing its watershed.

The estimated daily reduction in consumption in Manhattan and The Bronx reached a maximum of 71 million gallons in August, 1911, averaged 65 million gallons for the last 6 months of 1911 and almost 50 million gallons for the year 1912, while the total reduction since the beginning of the work in the fall of 1910 to April 1, 1913, aggregated over 39,700 million gallons. In Brooklyn the maximum reduction of 34 million gallons daily was effected in February, 1913, and the average daily reduction since August, 1912, the commencement of the house-to-house inspection, to April 1, 1913, amounted to 25 million gallons, while the total saving since the beginning of the pitometer work in July, 1910, to April 1, 1913, aggregated over 9,000 million gallons. This reduction in consumption in the borough of Brooklyn was such that the average daily consumption for the month of January, 1913, would give a per capita consumption of only 73 gal., which is the lowest per capita consumption for any January since 1894, or for the last 19 years.

The aggregate value of the water thus saved, if figured at meter rates, $133 per million gallons, would be nearly $6,500,000 and the total cost of the work done to effect this saving was about $167,000, which would be reduced to $131,000 if the amount for fines imposed (i.e., $36,000) were deducted.

The per capita consumption for New York City for 1910 (111 gal.) was lower than that of the next five largest cities in the United States, i.e., Chicago, Philadelphia, St. Louis, Boston and Cleveland, for the year 1912; and this in spite of the fact that in New York a floating population of many thousands, not included in the census, is housed, and that there are an equally large number who live outside the limits of New York City, but who work in the city, also left out of the census. If this transient population were considered, the per capita consumption in New York would be materially reduced. Compared with other American cities, New York, therefore, is economical in the use of water, even if we include our waste.

Preventable Waste.—For the purpose of this report, "waste" shall be considered as the quantity of water drawn in excess of that required for the uses already specified, and will be designated as "preventable" when the value of the water wasted is greater than the cost of the methods required to save it, whence it follows that it would be considered non-preventable when the reverse conditions obtain, so that "it will not pay" to save the water, these designations being based exclusively on practical and economical considerations. For "value" must be understood not simply the normal money cost or selling price of the water, but also the increase or decrease due to the condition of the supply at the time. The author has held before that under existing conditions in New York it would not be advisable in making a safe estimate, to assume a larger permanent saving in consumption from the work to prevent waste, than from 15 to 20 per cent., and the results recently obtained seem to bear out these figures.

Reducing Waste.—The following methods are generally employed:—

1. Calling to the attention of consumers the need of checking waste, either for economical considerations or to prevent a threatened shortage on account of inadequate supply, or for both reasons.
2. House to house inspection to detect and repair leaks.
3. Examination for leaks outside of the buildings, in service pipes as well as distribution mains and appurtenances, to locate and repair underground leaks.
4. Metering of all connections where the cost and existing conditions of the supply warrant this measure.

The fourth method cannot under existing legislation be generally applied in New York, nor was it available for the work under consideration. Under the existing legislation, the water department can compel the installation of meters by property owners only in buildings where water is used for commercial purposes, so that out of a total of 365,000 services, only 86,000 or less than one-fourth, are metered, and of this number 60 per cent. are in the Borough of Manhattan.

Public and Individual Notices.—Public attention was repeatedly called, through the press, to the inadequate supply available in those boroughs in which existing conditions warranted such a statement, the requisite data being also given in support thereof and the imperative need shown of preventing waste in order to avoid a threatened shortage; while a notice printed in English, Italian and Yiddish was delivered at all premises requiring consumers to stop all leaks in their fixtures, advising them at the same time that the department would impose a fine if after the first inspection leaky fixtures were not promptly repaired. These notices, forwarded about the middle of June, 1911, met with instant and efficient response, so that a large reduction in consumption resulted at once.

House to House Inspections.—The larger portion of waste in the city of New York is due to defective fixtures within the buildings, and especially to the water lost from roof and toilet tanks, and leaks from the latter are also the most difficult to detect, as the escape of water is not always apparent to the eye, although the noise made is sufficient, as a rule, to enable the occupant of the premises to detect the leak. Next to leakage of tanks is that from faucets, due either to their being carelessly left open or to need of repairs usually resulting from wearing out of washers.

The Board of Estimate and Apportionment having approved the issue of $100,000 revenue bonds to pay for a house to house inspection, a force of about 100 inspectors was placed in the field in June, with the necessary clerical force to handle the inspection reports, notices of leakage, etc., this force operating under the direction of the water registrar. The Engineering Bureau determined the amount of water consumed before and after house to house inspection, and for this purpose 18 districts were laid out in the borough of Manhattan. The flow into these districts was determined by pitometer measurements, and a record of the reduction in leakage resulting from the inspection was thus obtained. The house to house inspection was continued with full force until September, when the reduction in consumption, together with the increased rainfall, made it unnecessary to prosecute the work as vigorously as in the early part of the summer. At least two inspections were made in each building where leaks were found.

The results of the work done are shown by the following table of consumption, in which the reduction has been approximately apportioned between the work done in stopping leaks in mains and the work done in stopping leaks and waste in buildings:—

Month	Consumption in Manhattan and Bronx, million gallons per day 1910	1911	Estimated consumption assuming increase of 3 per cent. equivalent to rate of increase in population 1911	Estimated reduction in consumption, million gallons daily: By stopping underground leaks	By reducing leakage and waste in buildings	Total
January ..	335	334	345	4	7	11
February .	336	331	346	4	11	15
March....	327	327	339	6	4	10
April	326	320	336	6	10	16
May......	326	310	336	8	18	26
June	329	286	339	9	44	53
July......	342	287	352	9	56	65
August ..	336	275	346	9	62	71
September	335	277	345	10	58	68
October ..	332	278	342	11	53	64
November	321	271	331	11	49	60
December	333	283	343	11	49	60

Due attention was given to the measurement of flow in pipes and mains outside of buildings, to locate and stop leaks. As investigations made in 1910 had shown some large leaks, especially in mains laid under the East River, and as there was great likelihood of leaks along the river that discharged into it and therefore did not show on the surface, careful measurements were made of the flow of water in various parts of the city to locate these underground leaks, particular attention being given to the river front, and a special division for this class of work was formed, to which were assigned men who had experience in similar work in this and other cities. Broken mains were also found where the loss of water was very great. In one instance, where the broken main lay at the bottom of the East River, the loss amounted to over 3 million gallons per day.

The underground leakage stopped was about 10 million gallons daily, which, if valued at meter rates, would amount in a year to nearly $500,000, while the cost of this work, covering a period of about two years, was $19,000, or say $9,500 per year.

Results Obtained.—The average daily consumption of Manhattan and The Bronx was 331 million gallons in 1910, giving a per capita consumption of 120 gallons. On the basis of the consumption figures for 1910, assuming an increase of 3 per cent. annually due to increase in population, the average daily consumption would increase to 341 million gallons in 1911 and to 352 million gallons in 1912. By the work to check waste, however, the average consumption for the year 1911 was reduced to 298 million gallons daily, or 105 gallons per capita, but the actual reduction was really greater than shown by the above average, as the effect of the water waste work did not show great results until July, 1911, when the reduction reached 65 million gallons daily and was thus maintained on average up to January 1, 1912.

While there was a natural increase in the consumption for the year 1912, the average daily consumption was only 303 million gallons, corresponding to a per capita consumption of 104 gallons. The consumption for the month of December, 1912, averaged 297 million gallons daily, which is less than the average daily consumption for the year 1904. On the basis of the estimated consumption for 1911, 1912 and 1913 some 39,000 million gallons have been saved, which if valued at meter rates, $133 per million gallons, would amount to about $5,187,000, at a cost to the city of about $100,000, exclusive of the fines imposed for leaky fixtures during the time of house to house inspection. The per capita consumption has been reduced from 120 gallons, which was the average for these two boroughs in 1910, to 101 gallons, which is the per capita consumption for the first quarter of 1913.

Through the large reduction in waste effected in Brooklyn, it will be possible to meet all the demands of consumers in that borough up to the time of the introduction of the Catskill supply, without the construction of additional works, and also to furnish several million gallons daily for the supply of Queens, where water is now purchased from private companies.

In Manhattan and The Bronx the per capita consumption has been reduced to 100 gallons, which is lower than the average per capita consumption of every city in this country having a population of half a million or more.

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CONTENTS OF THIS ISSUE.

HAMILTON'S RAILWAY PROBLEM.

The civic authorities in Hamilton have to deal with the opposition of the Toronto, Hamilton & Buffalo Railway in the matter of removing its line from the southern and residential section of the city to a more desirable strip along the bay front. The continual noise and smoke which has been associated with the Hunter Street station has developed an agitation which apparently will not subside without gaining its end. The city is desirous, furthermore, of concentrating all its railways, i.e., the G. T. R., the T., H. & B. (C.P.R.), and the proposed C.N.R. to a common route now used by the former along the water front.

The argument of the T., H. & B. is based upon the likelihood of the change being detrimental to its patronage. It appears that nearly 80 per cent. of the passenger traffic uses the Hunter St. station in preference to the Stewart St. station, while with the union station, which the authorities purpose building on a site near the latter, the patronage would probably be more equally distributed. In consideration of this, however, the city has offered the railway $1,000,000 to move, and City Engineer Macallum has located a proposed line which, in the matter of grades, excels the old route by such a margin as to be a handsome inducement to the railway to accept it.

It is claimed that the Hunter Street route has many disadvantages, from an engineering point of view. Among them the question of grades appears to be the most important, and being over one per cent., the grades have made a name for themselves as a disabling factor to continuous traffic by the stalling of many freights daily. The new route proposed by Mr. Macallum offers a grade of .64.

At any rate, the time has come for the elimination of level crossings, and if the railway authorities do not accept the city's proposal the depression of the tracks will likely ensue, although the company favors elevation, claiming an advantage in cost. It is likely that the Railway Board will shortly be presented with the case, and if it has not the authority to require the T., H. & B. to move, Parliament will likely be approached.

The city's request appears quite reasonable. It offers to indemnify the company for all reasonable loss, to provide a better grade and a route more suitable than the present one. In return the city desires to remove a railway line with its many inconveniences from its residential section, simultaneously eliminating a number of level crossings dangerous to life, detrimental to continuity of street traffic, and unsightly in the extreme.

AN ADVANCE IN ELECTRICAL ILLUMINATION.

Since the introduction of the incandescent lamp, over thirty years ago, the art of illumination has been as apt an example of meritorious study and its fruits as the world has had. From time to time during the interval from the great Edison discovery of the property of carbonized filament, up to the present, many additions of great utilitarian value have transformed the electric lamp from an experiment into a commodity upon which is dependent the health, comfort and general advance of civilization, and the commercial advantages of which alone have rendered possible an indeterminable production from accelerated industry.

Mr. J. S. Leese, a Manchester authority on illuminating engineering, was quoted in April 22nd issue of *The Canadian Engineer* concerning the use of metal filament and its economic value over carbon filament, together with the necessity of change in design and composition of globes and shades to offset the disadvantage of intense brilliancy and its effect upon the eye-sight, which had accompanied the newer filament, and which was considered serious in comparison with the softer light of carbon lamps.

The general displacement of the carbon lamp by that of metal filament has been further retarded to a considerable extent by items of first cost and short life. Its introduction, on the other hand, is due largely to the remarkably small amount of energy which it consumes. In this respect the argument in favor of the metal filament has been so potent as to overcome much pessimistic opinion created by the above-mentioned disadvantages.

The art of electrical illumination has now received an added stimulus in a report from the Schenectady laboratories of the General Electric Company to the effect that a type of tungsten lamp has been scientifically obtained that will consume less than one-half of the energy which the present lamp requires. This is obtained by enclosing the filament in an atmosphere of inert gas, such as nitrogen, the density of which is about the same as that of the surrounding air. It is claimed that the consumption of current in an ordinary tungsten lamp is thereby reduced to one-half watt per candle-power. The effect of this important attainment in the history of illumination is significant.

REVISED FIRE REGULATIONS FOR RAILWAYS.

An amendment to the Dominion Forest Reserves and Parks Act provides that "When a railway within a forest reserve is being constructed or operated by a company not under the jurisdiction of the Board of Railway Commissioners for Canada, the Minister of the Interior may require such company to establish and maintain an efficient and competent staff of fire rangers, equipped with such appliances for fighting fire or preventing fire from spreading as the said Minister deems proper, and to provide such rangers with proper and suitable equipment to enable them to move from place to place along the line of railway.

"The said Minister may require such company to maintain an efficient patrol of the line of railway and other lands in the vicinity thereof to which fire may spread, and, generally, may define the duties of such company, and of the said fire rangers, in respect thereof.

"For the purpose of fighting and extinguishing fire, the said fire rangers may follow fires which spread from the railway, to, over and upon any lands to which they may spread.

"The said Minister may require such company to make returns of the names of fire rangers in its employ in the performance of the said duties, and of the places or areas in which they are engaged."

The above amendment is similar to the provision in the Railway Act, applying to lines subject to the jurisdiction of the Railway Commission. In its last general order, dated July 4th, the Board enacted some important revisions respecting fire regulation. Among them the following differ most from corresponding sections of the old order dated May 22nd, 1912:—

"No employee of any railway company shall open the back dampers of the engine while running ahead, or the front dampers while running tender first, except when there is snow on the ground, and it is necessary to take such action in order to have engine steam properly."

"No such railway company shall permit fire, live coals, or ashes to be deposited upon its tracks or right-of-way, unless they are extinguished immediately thereafter, except in pits provided for the purpose."

"Every such railway company shall instruct and require its sectionmen and other employees, agents, and contractors to take measures to report and extinguish fires on or near the right-of-way as follows:—

"(1) Conductors, engineers, or trainmen who discover or receive notice of the existence and location of a fire burning upon or near the right-of-way, or of a fire which threatens land adjacent to the right-of-way, shall report the same by wire to the superintendent, and shall also report it to the agent or persons in charge at the next point at which there shall be communication by telegraph or telephone, and to the first section employees passed. Notice of such fire shall also be given immediately by a system of warning whistles.

"(2) It shall be the duty of the superintendent or agent or person so informed to notify immediately the nearest forest officer and the nearest section employees of the railway, of the existence and location of such fire.

"(3) The provisions of this section shall apply to all fires occurring within 300 feet of the railway track unless proof shall be furnished that such fires were not caused by the railway."

"Every such railway company shall give particular instructions to its employees in relation to the foregoing regulations and shall cause such instructions to be posted at all stations, terminals, and section houses along its lines of railway. In case said instructions are not also carried in employees' time tables during said prescribed period, or in 'operating' and 'maintenance of way' rule books, they shall, previous to April 1st of each year, be re-issued to all employees concerned, in the form of special instructions."

EDITORIAL COMMENT.

The council of the Canadian Society of Civil Engineers has appointed a committee to prepare a standard specification on reinforced concrete work. The following compose the committee: Mr. C. M. Morssen, Mr. Ernest Brown, Mr. P. B. Motley, Mr. Peter Gillespie, Mr. S. Baulne, Mr. E. S. Mattice, Mr. E. E. Brydone-Jack, Mr. H. M. MacKay, Dr. J. Galbraith, Mr. C. M. Monsarrat, Mr. H. Rolph, and Mr. Walter J. Frances, as chairman.

* * * *

The report of R. C. Harris, commissioner of works for the city of Toronto, relative to the extension of the waterworks system, and appearing in last week's issue of *The Canadian Engineer*, has been considered by the city council and adopted. A mechanical filtration plant to supplement the existing slow sand filtration plant will be established on Toronto Island. One million dollars have been set aside by the council for the installation, and it is understood that no time will be lost in getting the work under way.

FINENESS OF CEMENT AND RATE OF HYDRATION

IMPORTANT RELATION EXISTING BETWEEN THESE QUALITIES—RESEARCH SHOWS VALUE OF HYDRATION AS A TEST FOR FINE GRINDING—LIKELY TO SUPERSEDE THE SIEVE IN THE LABORATORY.

By HENRY S. SPACKMAN,

Consulting Engineer, Philadelphia.

A HITHERTO uninvestigated field of research is brought to the attention of engineers in a paper read by Mr. Henry S. Spackman, at the recent convention of the American Society for Testing Materials, at Atlantic City. It brings out well the possibilities of developing a test more thoroughly indicative of the efficiency of grinding, than the present sieving test.

The tests forming the basis of this paper were undertaken in connection with membership in a special committee of the International Association for Testing Materials, to which was assigned the problem of developing a method for the determination of fine flour in cement. The members were advised that there was no pre-determined programme for the investigation, but that each member of the committee was left free to proceed independently to determine which of the two proposed methods, namely, the separation of the cement, either by air or by liquid, into portions, according to the size of the particles—would best serve the purpose, or to develop another method if he thought it desirable that both processes be abandoned and replaced by another more reliable or simple one.

It was decided, in view of the fact that the other members of the committee were studying the separation of fine particles by liquid or air, to investigate what relation if any, existed between fineness of grinding on the one hand, and the decrease in specific gravity and increase in combined or chemically fixed water in the set cement on the other. While it was realized that such a relation, if demonstrated, would give no definite information as to the various percentages of the different sized particles present, it was thought that if either the decrease in specific gravity or increase in water of combination was shown to have a sufficiently constant relation to the amount of cement present in a fine enough state of subdivision to take part in the chemical reactions of setting and hardening, the purpose for which the committee was appointed would be accomplished. It was also thought, in view of the known fact that the chemical composition and degree of burning, as well as fineness of grinding, are important factors in determining the activity of particles of cement of a given size, that the determination of the rate and extent of hydration would be a more correct index of the value of the cement than the mere determination of the percentages of particles of various sizes present, as the effect of chemical composition and burning, as well as of fine grinding, would be included in any conclusions drawn from the determination of the rate and extent of hydration, as evidenced either by the content of combined water or decrease in specific gravity.

While the following tests are in no way conclusive, and are confessedly open to criticism for lack of completeness and crudeness of the methods employed, they are sufficiently concordant to suggest, if not to prove, the existence of a more or less definite relation between the fineness of grinding on the one hand, and the decrease in specific gravity and increase in the content of water of combination of the hydrated cement on the other.

In order to ascertain in a general way the rate of hydration of a normal cement, a commercial sample which passed the Standard Specifications of this society was made into neat briquettes. These were stored 24 hours in moist air, then submerged in water. Briquettes were taken at the several periods indicated in Table I., ground, dried to a constant weight at a temperature of 100° to 110° C., and the specific gravity determined.

Table I.

	Specific Gravity
Cement before gaging	3.17
Gaged Cement:	
24 hr. in air	2.86
24 hr. in air, 24 hr. in water	2.78
24 hr. in air, 6 days in water	2.74
24 hr. in air, 13 days in water	2.63
24 hr. in air, 20 days in water	2.57
24 hr. in air, 27 days in water	2.57

These tests, as might be expected, showed upon first hardening a marked decrease in specific gravity and a gradual decrease as hydration proceeded, up to the 21-day period, after which no decrease in specific gravity was noted, indicating for this particular sample the practical completion of the initial hydration prior to the 21-day period.

In order to ascertain whether the maximum hydration took place when the cement was in the form of a mortar, a sample of the same cement was placed in a test tube with water and agitated for 28 days. This, when tested in the same manner, gave a specific gravity of 2.47 and a loss on ignition of 15.52 per cent., indicating probably the maximum hydration attainable at 28 days under ordinary temperature conditions.

In order to determine the effect of the size of grains on the rate of hydration, another cement having a specific gravity of 3.17 and loss on ignition of 1.70 per cent. was tested. Twenty-gram charges of the cement as received, of the portion of the cement passing the 100-mesh and retained on the 200-mesh sieve, and of the portion that passed the 200-mesh sieve, were placed in test tubes with 50 c.c. of water, and continuously agitated for a period of 24 hours, then dried to constant weight at 100° to 110° C., after which the specific gravity and loss on ignition were determined on the three samples. The results are given in Table II.

Table II.

Cement	Specific Gravity of Hydrated Cement	Loss on Ignition, per cent, Before Hydration	Loss on Ignition, per cent, After Hydration	Increased Loss by Hydration, per cent.
As received after hydration...	2.94	1.70	5.22	3.52
Passing the 100 and retained on the 200-mesh sieve....	3.12	0.65	1.45	0.80
Passing the 200-mesh sieve...	2.84	1.95	6.17	4.22

In order to determine whether exposure to steam at atmospheric pressure would give at short periods hydration approximating that after a longer exposure in water, the same cement, in the condition it was received, the portion that passed the 200-mesh sieve, the portion passing the 100-mesh and retained on the 200-mesh sieve, and the cement after grinding in a laboratory ball mill for 1, 2 and 3 hours respectively, were made into neat mortar, allowed to stand in moist air for 24 hours, then subjected to steam at atmospheric pressure for 24 hours. The results obtained are given in Table III.

Table III.

Cement	Fineness, per cent passing sieves No. 100	No. 200	Specific Gravity of Hydrated Cement	Loss on Ignition, per cent. Before Hydration	After Hydration	Increased Loss by Hydration per cent.
As received........	95.6	77.8	2.66	1.70	8.58	6.88
Ground 1 hr........	99.8	91.0	2.60	1.70	9.41	7.71
Ground 2 hr........	100.0	97.0	2.59	1.70	9.33	7.63
Ground 3 hr........	100.0	99.0	2.58	1.70	10.93	9.23
Passing 100 and retained on the 200	100.0	00.0	3.03	0.65	1.60	0.95
Passing the 200 sieve	100.0	100.0	2.63	1.95	10.17	8.22

In order to determine whether subjecting the cement to the action of steam at high pressures and temperatures would show a further decrease in specific gravity and increase in water, of combination, another cement was made into briquettes. A part of these were subjected, after exposure, to moist air for 24 hours and to a steam pressure of 20 atmospheres in an autoclave for 2 hours. Table IV. shows the specific gravity, loss on ignition, and content of carbon dioxide and combined water, of briquettes exposed to moisture in the ordinary way and to high steam pressure in the autoclave.

Table IV.

Cement	Specific Gravity	Loss on Ignition, per cent.	Content of Carbon Dioxide, per cent.	Content of Combined Water, per cent.
Before hydration..........	3.16	0.50	0.40	0.10
Hydrated in moist air for 24 hr.	2.74	6.90	1.25	5.65
After hydration in air and exposed to steam pressure or 20 atmospheres for 2 hr.	2.63	9.60	1.35	8.25

In the absence of any known data showing the specific gravity of a completely hydrated cement, a sample of another brand of cement was taken as received, made into a slurry with 60 per cent. of water, placed in a laboratory ball mill, ground for 8 hours and allowed to stand over night. This cement, on examination next morning, was found to be partially set. Water to the amount of 60 per cent. of the original weight of the cement was added, grinding continued for 8 hours, and a sample taken for analysis. The cement was allowed to stand over night as before. The next morning, while not set, it was found to be too thick to allow of continuing the grinding; and a third addition of water to the amount of 60 per cent. of the original weight of the cement was added, making a total of 180 per cent. of water necessary to make the mixture sufficiently fluid to grind properly. Samples were taken at the expiration of the third day's grinding and at the expiration of the fifth day's grinding. After drying to constant weight at 100° to 110° C., the specific gravity of these samples was determined and analysis made for carbon dioxide and combined water. The results are given in Table V., and indicate a possible specific gravity of completely hydrated cement below 2.3 and a content of chemically combined water of above 15 per cent. It is doubtful whether so great a hydration ever occurs in practice, even after long exposure to water, altrhough the individual particles may have even lower specific gravity.

Table V.

Cement	Specific Gravity	Loss on Ignition, per cent.	Content of Carbon Dioxide, per cent.	Content of Combined Water, per cent.
Before hydration........	3.12	1.50	1.20	0.30
After 2 days grinding....	2.27	15.50	2.60	12.90
After 3 days grinding....	2.27	16.90	2.50	14.40
After 5 days grinding....	2.27	18.05	2.50	15.85

While the above tests and others made in our laboratory show that a relation exists between fineness of grinding and the rate and extent of hydration of Portland cements, it remains to be determined whether this relation is sufficiently definite to admit of its forming a basis for the development of a test which will replace the use of sieves in the commercial laboratory.

We regret that we were unable to carry out our intention of repeating these tests a sufficient number of times to determine whether the phenomenon of hydration was sufficiently positive to prevent the results obtained being markedly affected by unavoidable variations in the conditions under which the test was made, and also to ascertain whether it was possible for different operators working on duplicate samples to check each other.

We had also hoped, by working on synthetic mixtures of cement containing known quantities of different sized particles, to develop whether any definite relation existed between the content of particles below a certain size and the extent of hydration; also to find an explanation for the anomaly shown by these tests, of the cement being able after hydration had proceeded to a certain point to fix additional water without a corresponding reduction in specific gravity being apparent; also to determine the changes in specific gravity and combined water of cement mortars during long periods of storage under water.

C.P.R. ELECTRIFICATION.

Following the announcement in *The Canadian Engineer* for July 3rd, of the intention of the Canadian Pacific Railway to electrify a section of its line in the Rocky Mountain division, comes a proposal to the city of St. Catharines, from one of the company's representatives, of an electric line from Hamilton to the Niagara River. The city is asked to contribute one-half of the cost of a railway bridge across the old Welland Canal. As an alternative proposition, the C.P.R. is willing to use a bridge jointly with the Canadian Northern Railway, which also intends to build through St. Catharines. In such a case the C.P.R. would pay one-third of the cost and expect the Canadian Northern and the city to bear similar proportions.

The city council looks favorably upon the proposition and will take up the new proposal with the Canadian Northern Railway, which has under consideration the building of a railway and vehicular bridge across the old canal, for which the city is asked to contribute $100,000 and grant a fixed assessment of property, the company to enter the city on a residential street, to which route there is considerable opposition.

The seventh annual convention of the National Society for the Promotion of Industrial Education will be held in the city of Grand Rapids, Mich., October 19-25th inclusive.

WOOD BLOCK PAVEMENTS.

Their Development in the United States, and Specifications Governing Their Use.

By Mr. Geo. W. Tillson,
Consulting Engineer, New York City.

THE earlier wood pavements, including the old cedar block pavements and the first surfacings in the use of chemically treated blocks, is discussed in a paper by Mr. Tillson presented at the Third International Road Congress, London, England. The paper is an excellent resumé of present practice, and contains a summary of the requirements of the specifications of the principal cities of the United States using wood block as a paving material. The following, relating to the construction of wood pavements with treated blocks, is extracted from his paper:—

The city of Indianapolis, Ind., was the first city to take up seriously the question of laying chemically treated wood block. This city in 1896 laid a few streets with blocks of red cedar from the State of Washington. The contract for this work provided that the blocks should be thoroughly dried in a vat at a temperature of 200° F. and then submerged in creosote oil heated to a temperature of over 200° F. and remain there for at least 6 hours. It was estimated that this treatment would amount to about 3 lbs. of oil per cubic foot. The blocks were laid at an angle of 45° with the curb, no provision being made for expansion, and the joints were filled with paving pitch. These streets gave a little trouble on account of bulging caused by swelling of the pavement in wet weather, but not to any great extent. These pavements are still in use and said to be in a splendid state of preservation. These streets were so satisfactory that a more elobarate treatment was undertaken subsequently, the blocks receiving a treatment of 10 lbs. of creosote oil per cubic foot, with certain specification requirements for the oil.

As a result of some investigation in the method of treating blocks there was devised a method which was known as the creo-resinate process. This consisted of impregnating the blocks with a mixture composed of one-half creosote and one-half resin, the early specifications having no requirement for the character of the oil; the idea being that as the creosote was a good preservative, if it could be kept in the blocks they would last until they were worn out, but if used by itself, being so volatile, it would evaporate and the blocks would decay long before they had become destroyed by traffic. The object of the creosote then was to preserve the blocks and of the resin to prevent the volatization of the oil. The first pavement of this character was laid on Tremont Street, Boston, opposite the Common, in 1900. This pavement in the latter part of 1912 was said to be in such good condition that it would probably remain intact for 10 years. In 1902 a sample pavement of one block was laid in Brooklyn, N.Y., with creo-resinate blocks, and later a general specification for same was adopted. This required that the wood should be long leaf yellow pine and that the blocks should be treated with a mixture composed of one-half creosote oil and the other half resin or some other suitable waterproofing material; no attempt was made to regulate the character of the oil. The blocks were to have such waterproof qualities that, after having been dried in an oven for 24 hours at a temperature of 100° F., they should not absorb more than 3 per cent. of water after having been immersed for 24 hours. It was also required that all blocks after treatment should sink in water. The object of requiring the immersion test was that the blocks should be so treated that they would be stable in size, not swelling in damp weather, and so, by bulging, causing deformation of the pavement, nor shrink to an undue extent in dry weather. The requirement that the blocks should sink in water was made because it was realized that it would be somewhat difficult to ascertain how much treatment was given to the blocks, the process being carried out some miles from the city, and it was thought that if they sank in water it would be proven that approximately 20 lbs. per cubic foot had been used or that the blocks were of such a character as not to require so much treatment. The blocks were laid on a ½-in. mortar bed formed of 1 part Portland cement and 4 parts sand, this mortar bed being spread on a substantial concrete foundation. The joints between the blocks were filled with fine dry sand, and the pavement was laid without expansion joints. Almost no trouble has occurred on city streets laid under these specifications on account of bulging.

It soon developed that if much of this class of pavement was used and the same amount of resin as of oil used that the cost of the treatment would be very large. Consequently in the borough of Manhattan, New York City, a specification was adopted by which only 25 per cent. of resin was required, but the specific gravity of the oil was fixed at 1.12. In the course of a few years the question arose as to the propriety of doing away entirely with the resin and using only creosote oil. A committee was appointed by the Board of Estimate and Apportionment of New York City, consisting of the pavement engineers of the different city boroughs, together with the chief engineer of the board and chief engineer of the Finance Department, to prepare a standard specification for wood block pavement. This committee investigated the matter carefully and adopted a specification omitting the resin entirely and having the following requirements for the treatment of the blocks:—

The blocks shall be so treated with an oil elsewhere described that the pine blocks shall contain not less than 20 and the gum blocks not less than 22 lbs. per cu. ft. After treatment the blocks are to show such waterproof qualities that after being dried in an oven at a temperature of 100° C. for a period of 24 hours, weighed and then immersed in clear water for a period of 24 hours and again weighed, the gain in weight is not to be more than 3½ per cent. for pine blocks and 4½ per cent. for gum blocks.

The oil with which the blocks are to be treated shall be a stable, antiseptic and waterproofing oil from which the water has been removed by distillation, and which shall have a specific gravity of not less than 1.12 at 38° C. When distilled in the manner hereinafter described, the oil shall lose not more than 35 per cent. up to a temperature of 315° C. The distillate between 255° C. to 315° C. shall have a specific gravity not less than 1.02, the said specific gravity being taken at a temperature of 60° C.

Some of the manufacturers who appeared before the committee argued in favor of the use of oil manufactured from water gas tar. The committee did not feel that there had been sufficient experience to warrant this, but was willing that a mixture of water gas tar oil and coal tar oil should be used; provided, however, that not more than 50 per cent. of water gas tar oil should be used. The requirement that the distillate between 255° C. and 315° C. should have a specific gravity not less than 1.02 at a temperature of 60° C. was made in order to maintain this limit.

The foregoing gives briefly the development of the specifications for creosoted paving blocks in the East. In other sections of the country the process was about the same, except possibly the provision in New York specifications allowing the mixing of oil from water gas tar with coal gas tar oil for the preservative; and it is extremely doubtful if this provision was ever taken advantage of in New York.

In considering requirements for specifications for wood pavements, there are several points that must be taken into account, some of which the municipal engineers are generally agreed upon and others upon which there is a wide difference. These points are: kind of wood to be used and the size of the blocks, the character of the preservative as well as the amount to be used, the cushion coat on which the blocks are to be laid, the filler for the joints, and the necessity for an expansion joint.

Kind of Wood.—The cost of lumber in the United States during the last few years has been so great that the first cost of the blocks is an important consideration, and while it is generally considered that long leaf yellow pine makes the most durable blocks, it is questionable if other varieties cannot be used either locally or on light traffic streets. The kinds of wood generally admitted by the different specifications are: Long leaf yellow pine, black gum, Norway pine and tamarack. It is probable, however, that if the work is to be done in the far West, some such wood as Oregon fir or Washington cedar could be substituted for these other materials with good results. As has been said, the long leaf yellow pine makes an extremely durable pavement, but it is produced only in one section of the country, so that transportation charges are high, and, when the traffic and local conditions will permit, it is desirable to use a cheaper material.

Some four or five years ago the United States Government laid as an experiment, on a street in Baltimore, a wood pavement made up of a great many different kinds of wood, all treated with 1.09 creosote oil, the idea being to ascertain the relative merits of these different kinds so that a selection of material could be made according to the traffic on any particular street or the availability of any material. The kinds of wood used were long leaf pine, Norway pine, tamarack, Douglas fir, Western larch, white birch and hemlock. The long leaf pine was used to serve as a standard of comparison. The conclusion reached after the examination of the pavement, four years after it had been laid, was that:—

The species used will be tentatively grouped in accordance with the results of this inspection in the order of their value for creosote oil-paving material as follows:

1. Long-leaf pine.
2. Norway pine, white birch, tamarack, eastern hemlock.
3. Western larch.
4. Douglas fir.

In the East, as a matter of fact, the long leaf yellow pine has been used almost entirely up to the present time, the principal exception being black gum. This, however, has not given entirely satisfactory results. The yellow pine, while particularly good as to wearing qualities, is, for that very reason, more slippery and from the formation of the wood liable to split, so that the blocks are often destroyed when taken up to permit of carrying on any underground work. It is probable, however, that on the whole it is the most satisfactory wood for general use.

In the West tamarack has been used slightly, with very satisfactory results.

Size of Blocks.—Not very much difference exists in the practice of the engineers on this point. The first blocks were generally 4 ins. in width, but the more recent practice has been to reduce this width to 3 ins. The permissible length is generally from 5 or 6 to 10 ins., this range in length being given so as not to increase the price by selecting lumber all of one particular width. A difference of $1 per M. ft. in the price of the lumber adds 4 cents per yard to the cost of the pavement. The depth should be governed by the traffic on the street, although, as the blocks are small, they must have sufficient depth to be stable, irrespective of traffic. The indications are from the present experience that the actual wear from traffic on hard pine blocks on an average street is very little, and that, so far as that is concerned, a block 3½ ins. deep would probably last for 20 or even 25 years. Its tendency to split, however, makes it advisable to use a greater depth if the funds will permit.

In this connection it might be said that a small bridge was paved in Brooklyn some years ago with wood blocks, laid upon an old wooden foundation that was extremely irregular and not solid enough to preserve the surface of the pavement under the traffic to which it was subjected. The blocks soon split into pieces averaging about 2 ins. square, but, on account of their not being disturbed, the pavement was very durable, lasting some three or four times longer than the surface which had been previously used.

Character and Amount of Preservative Used.—This is a point upon which there is a great divergence in the practice of different engineers. In determining it, however, it should be understood that the preservative has two functions, one to act as an antiseptic and so prevent the block from decay, and the other to act as a waterproofing material, so that the blocks may remain stable and not absorb water, causing expansion when wet, or allowing too much contraction in a dry spell and thus making the blocks loose. Although an oil of antiseptic properties is desirable, it is probable that if water could be kept entirely from the inside of the blocks there would be no decay. This, however, is an exceedingly difficult matter and probably impossible. It seems desirable that a preservative should be selected that in itself will be stable and remain in the blocks as long as possible, for on residence or light traffic streets the life of a wood pavement will be determined mainly by its ability to withstand decay and not the wear and tear of traffic.

The two main points at issue in the character of the preservative are its specific gravity and its origin. Some argue that the specific gravity of the oil should be approximately from 1.08 to 1.12, the so-called heavy oil, and others from 1.03 to 1.06, the so-called light oil; some also argue that the oil should be a distillate of coal tar, while others would admit oil manufactured from water gas tar. The experience of the past in treating wood demonstrates that an oil from coal tar does make a good preservative, and while the same results might be obtained from a water gas tar product, the experience with this material has not been such as would warrant engineers using it freely. The borough of Manhattan, New York City, is laying an experimental wood pavement, which, among other features, will have blocks laid with coal tar oil and water gas tar oil under similar conditions, both as to material and traffic, making an attempt to determine the relative merits of these two oils. The advocates of the heavy oil recognize that it is not absolutely a distillate oil, and so not similar to what is generally recognized as creosote, but that its specific gravity is attained by combining distilled creosote oil of approximately 1.05 specific gravity with coal tar from which the water, light oils and excess of free carbon have been removed.

In the construction of wood pavements with creosote oil a certain amount of trouble has been caused by the exudation of the preservative upon the surface of the blocks soon after they have been laid, especially in hot weather, causing great inconvenience, particularly to foot passengers, as the surface is often covered with a thick, tarry substance which is exceedingly disagreeable. This exudation occurs when both the light and the heavy oils are used, although the advocates of light oil claim that it occurs much more frequently and to a greater extent with the heavy oils.

Quantity of Oil.—This is a point, too, upon which engineers differ, the quantities used for pine and similar blocks ranging from 14 or 15 lbs. up to as high as 20 lbs. per cubic foot. The quantity of oil used would undoubtedly make a material difference in the amount of exudation in hot weather, but this exudation does not continue for an extended length of time, and it can be taken care of by spreading sand over the pavement surface so as to absorb the exuded material. The action which causes it necessarily brings the material to the surface of the block, so that the pores at the surface must be thoroughly filled, and so cause the block to be as nearly waterproof as it possibly could be, giving after this excessive exudation has ceased a perfect surface so far as absorption of water is concerned. Experiments and experience are necessary in order to determine just what is the required amount of oil to be used. Its cost makes it an important factor in the cost of the pavement, so that it is important that no more should be used than is necessary. At the present time it is considered that on a heavy traffic street less oil can be used per cubic foot than on one of light traffic.

The early Brooklyn pavements referred to were all laid on a cushion coat of sand and Portland cement, mixed in proper proportions and with just enough water to allow the mortar to set. The blocks were rolled down to an even, smooth surface and not disturbed until the cushion coat was thoroughly hard. Recently a cushion of sand has been used in many instances, but the author believes that the mortar cushion gives the best results. It might be claimed that the pavement could be opened for traffic more quickly if a sand cushion were used than with one of mortar, but if traffic is kept completely from the pavement, the blocks can be laid before the foundation concrete has thoroughly set, so that the setting of the cushion coat and the concrete base can go on simultaneously.

Joint Filling.—The practice in this regard has been to use sand, cement and bituminous fillers. The advocates of the sand filler claim that if a fine dry sand is used the joints will be completely filled and that under traffic the surface of the street soon becomes practically homogeneous and that the sand in the joints will absorb a certain amount of the exudation of the preservative from the blocks and so make an absolutely waterproof joint. The advocates of the cement grout filler argue that it is necessary to use this material so that the joints will be absolutely full and remain full. The grout when used is generally made up of a mixture of 1 part of sand and 1 part of Portland cement, with enough water to flow freely into the joints. The opponents of this method argue that unless the pavement is kept free from traffic long enough to thoroughly set, which it is difficult to do, the bond of the mortar is broken, and even if not broken, it has not sufficient strength to resist traffic, so that in either event nothing better than a sand joint is obtained notwithstanding the increase in price. The advocates of the bituminous filler argue that if the joints are filled with coal tar or an asphaltic preparation, or some other similar substance, each joint is practically an expansion joint and that it will allow a certain expansion of the pavement as a whole without any bulging which with the same expansion would take place if a solid filler like sand or cement grout were used. The opponents argue that by the use of this filler, when the preservative exudes from the blocks, as it must to a certain extent, the bitumen in the joints simply adds to the nuisance which is caused by the exudation of the preservative on the surface of the street. In actual practice the sand and bituminous fillers are most generally used.

Expansion Joint.—Although the treatment of the blocks is supposed to prevent the absorption of water, causing expansion of the pavement, in practice it is impossible to have the blocks entirely waterproof, so a certain amount of expansion must take place. Provision for this is made by allowing a space along the curb, which is filled with some kind of bituminous material. For a roadway 30 ft. wide this expansion joint is generally from ¾ to 1 in. in width. No provision is made for taking care of longitudinal expansion, except in the city of St. Louis, although the pavement is continuous for a distance many times the width of the street. No more trouble seems to be caused by expansion in this direction than transversely. Some claim that the bulging is produced by the transverse expansion on account of the crown of the pavement, so that when the pressure is created the resistance to the lifting of the pavement is less than to the compression of the blocks and the result is that the pavement bulges along this line of least resistance. This theory might, to a certain extent, account for the lack of bulging by longitudinal expansion.

In the Brooklyn and Manhattan pavements no expansion joints are provided for, and as far as has been said, very little trouble has been caused by bulging when the material has been yellow pine and when the absorption test has been maintained. The result of this experience would seem to demonstrate that in the climate of New York City, at least, no expansion joint is necessary.

Specifications for Wood Block Pavement.—In the United States there are two organizations which have taken up in detail the matter of wood block specifications. Both are formed of city officials, and one is known as the American Society of Municipal Improvements, the other as the Organization for Standardizing Paving Specifications. This latter organization has had three meetings and has adopted specifications for wood pavements at each meeting; the American Society of Municipal Improvements has adopted specifications at one meeting only.

So that it may be known what the practice is of the engineers of the principal cities of the United States using wood pavements, the requirements of the specifications, as well as those of the two organizations, will be given on each of the general points previously discussed. In this statement the American Society of Municipal Improvements will be designated as "The Society" and the Organization for Standardizing Paving Specifications as "The Organization." It must be remembered that the specifications are constantly changing, but those here given represent the practice in 1912.

Kind of Wood.

The Organization.—Southern yellow pine, Norway pine, black gum, tamarack.

The Society.—Long leaf yellow pine, Norway pine or tamarack.

Borough of Manhattan, New York City.—Southern long leaf yellow pine.

Chicago.—Southern yellow pine and tamarack.

Cincinnati.—Southern yellow pine, Norway pine or tamarack.

Philadelphia.—The same as the organization.

Minneapolis.—Southern yellow pine, Norway pine, Washington fir or tamarack.

St. Louis.—Southern yellow pine.

Size of Blocks.

The Organization.—5 to 10 ins. long, to average 8 ins., 3 to 4 ins. in width, 4 ins. in depth, except on medium traffic and light traffic streets or alleys, where the depths can be reduced to 3½ and 3 ins., respectively.

The Society.—5 to 10 ins. long, to average 8 ins.; 3½ to 4 ins. in depth and width, according to traffic; light traffic streets, 3 ins. in depth.

Borough of Manhattan.—8 ins. long, 3 ins. in width, 4 ins. in depth.

Chicago.—5 to 10 ins. long, to average 6 ins.; 3¾ ins. in width, depth 4 ins., except in special cases.

Cincinnati.—6 to 10 ins. long, to average 8 ins.; 3 ins. in width, 3½ ins. in depth.

Philadelphia.—Same as the Organization.

Minneapolis.—5 to 10 ins. long, to average 8 ins.; 4 ins. in width, 3¼ or 4 ins. in depth.

St. Louis.—Not less than 6 ins. long, to average 8 ins.; 3 or 4 ins. in width, not less than 3½ ins. deep.

Character of Treatment.

The Organization.—Specification A: The preservative to be a product of coal gas, water gas, or coke oven tar, free from all adulterations contained in raw or unfiltered tars, petroleum compounds, or tar products obtained from processes other than stated; specific gravity not less than 1.10 nor more than 1.14 at a temperature of 38° C.

Specification B: Preservative to be a distillate of coal gas or coke oven tar, free from all adulterations, and contain no raw tar, filtered or unfiltered tars or pitches, petroleum compounds, or other tar products; specific gravity not less than 1.03 nor greater than 1.08 at 38° C.

The Society.—Oil to be a coal tar product, free from adulteration of any kind; specific gravity at least 1.10 at a temperature of 38° C.

Borough of Manhattan.—Oil to be a stable, antiseptic and waterproofing oil from which the water has been removed by distillation, and which shall have a specific gravity not less than 1.10 at 38° C. (Further description given in previous portion of this paper.)

Chicago.—Oil to be a distillate oil obtained only by distillation from coal tar; no other material of any kind to be mixed with it; specific gravity to be not less than 1.08 and not more than 1.12 at 25° C.

Cincinnati.—Oil A: The oil to be the best obtainable grade of coal tar creosote, a pure distillate of coal tar and free from admixtures of oils, tars or substitutes that are not pure coal tar; specific gravity to be at least 1.04 at a temperature of 38° C.

Oil B: The oil to be of a coal tar product, free from adulteration of any kind whatever; specific gravity to be at least 1.10 at a temperature of 38° C.

Philadelphia.—The same as The Organization.

Minneapolis.—Oil to be a pure heavy coal tar product only; specific gravity to be at least 1.10.

St. Louis.—The preservative to have a specific gravity of not more than 1.08 at a temperature of 38° C.

Amount of Treatment.

The Organization.—Pine and tamarack blocks to contain not less than 18 lbs., and gum blocks not less than 22 lbs. per cu. ft.

The Society.—20 lbs. per cu. ft.

Borough of Manhattan.—20 lbs. per cu. ft.

Chicago.—20 lbs., probably to be changed to 16 lbs. per cu. ft.

Cincinnati.—18 lbs. per cu. ft.

Philadelphia.—Same as The Organization.

Minneapolis.—No amount specified, but to be so treated as to be impervious to water and to prevent decay.

St. Louis.—16 lbs. per cu. ft.

Each specification contains requirements for the amount of the distillate at certain temperatures, but they do not vary much for the same kind of oil.

Cushion.

The Organization.—Cement mortar composed of 1 part of Portland cement and 4 parts of sand, not to exceed 1 in. in thickness; under special conditions mortar cushion to be omitted and a bituminous coating substituted therefor.

The Society.—Either a sand cushion 1 in. in thickness or mortar 1 in. in thickness made of 1 part of Portland cement and 3 parts of sand.

Borough of Manhattan.—1 in. of sand.

Chicago.—1 in. of sand, or ½ in. of mortar.

Cincinnati.—Either sand or mortar 1 in. in thickness made of 1 part of Portland cement and 3 parts of sand.

Philadelphia.—Mortar, 1 part Portland cement and 4 parts sand, not less than 1 in. thick.

Minneapolis.—1 in. of sand.

St. Louis.—1 in. of sand.

Joint Filler.

The Organization.—Suitable bitumen, or, when the blocks are laid upon a mortar or a bituminous cushion, sand.

The Society.—Sand.

Borough of Manhattan.—Sand.

Chicago.—Asphaltic pitch, cement grout, or sand.

Cincinnati.—Sand.

Philadelphia.—Sand.

Minneapolis.—Pitch.

St. Louis.—Sand.

Expansion Joints.

The Organization.—Not less than ¾ in. along the curb, filled with a suitable bituminous substance.

The Society.—¾ in. along the curb, filled with a suitable bituminous substance; on streets 50 ft. or more in width a second expansion joint similar to the other, separated from the first by a row of blocks; on heavy traffic streets, if deemed advisable by the engineer, expansion joints can be omitted.

Borough of Manhattan.—None.

Chicago.—1½ ins. along the curb, filled with a bituminous substance.

Cincinnati.—Similar to the Society's requirements.

Philadelphia.—¾ in. along the curb, filled with a bituminous substance.

Minneapolis.—1 in. along the curb, filled with pitch.

St. Louis.—1 in. along the curb and at intervals of about 100 ft. across the street at the direction of Street Commissioner, to be filled with a mixture of bituminous material and hard mineral dust.

Since the introduction of treated wood as a paving material it has increased in popularity very rapidly. It was seriously handicapped by the experience of the cities in the past, but, when the officials realized that by chemical treatment the wood would be preserved from decay, it soon came into general use. It has so many good qualities, the chief one being possibly its almost complete noiselessness, and its principal, and perhaps its only bad quality being its slipperiness, that property owners were quick to appreciate it despite its increase in cost over asphalt and other smooth pavements. The slipperiness of wood is experienced only when the surface of the pavement is frosty or damp, or when the grades are excessive. The former trouble exists only in a comparatively few days of the year, and can in a great measure be obviated by proper sanding; the latter can be prevented by judicious action in laying the pavement. The author's practice has been not to lay wood blocks on a continuous traffic street on grades of over 2 per cent.

In considering this question of slipperiness, however, it should be noted that Minneapolis, Minn., which has probably the largest amount of creosoted wood pavement in the country, reports that it has had no trouble whatever from slipperiness, and the city of Great Falls, Mont., also makes the same report. This is exceedingly interesting, when from other cities has come the most positive statements regarding the slippery properties of the pavement.

The popularity of wood as a paving material is illustrated by its present use. The city of New York alone awarded in 1912 contracts amounting to 320,000 sq. yds., while the amount laid in the United States previous to December 31, 1911, was 5,670,000 sq. yds., and it was estimated that from 2,000,000 to 2,500,000 sq. yds. would be laid in 1912. The cost of this pavement varies according to local conditions and specifications, but it averages from $3.25 to $3.50 per square yard, the blocks being 4 ins. deep, laid on a foundation of Portland cement concrete 6 ins. thick.

Repairs.—Very little information can be obtained of the cost of repairs to or maintenance of creosoted wood pavements, because these pavements have practically all been laid under a guarantee by which the contractor is obliged to keep them in repair for five years without extra cost, and also because, after the pavements are out of guarantee, although the repairs are made by the employees of the highways departments, still no exact record of costs has been kept in most cases. The pavement on Tremont Street, Boston, referred to earlier in this paper, has been in use 12 years and has cost absolutely nothing for repairs, and it is stated by the engineer in charge of the Boston pavements that the same is true of some other 14,000 sq. yds. which were laid at about the same time and in the same way. In the borough of Brooklyn, New York City, the first creosoted wood pavement was laid in 1902, without any guarantee, and has cost absolutely nothing for repairs. Pavements that were laid later and have been out of guarantee for 3 to 4 years, have been kept in repair by the borough and an accurate record kept of their cost. Some of the streets have cost absolutely nothing, and the average cost for the entire area out of guarantee has been 1 1/20 cents per yard per year. Many of these pavements, however, have been opened for sub-surface work, and the engineer in charge of pavements states that in his opinion practically all of the repairs are due to settlements over trenches, and damage caused by fires, and not to actual wear and tear of traffic. The borough of Manhattan, New York City, has three streets which have been out of guarantee 3 years, one of heavy traffic, one of medium traffic and one of light traffic. The heavy traffic street has cost 7 cents per yard per year, while the average of all has been 6 cents per yard per year; but it should be explained here, as in the case of the Brooklyn streets, that the repairs have been due to wear and tear only on the heavy traffic street, which is a wholesale street in the business section. Repairs on the other streets are due to settlements over trenches, damage caused by fire, and practically nothing to wear and tear of traffic.

The city of Minneapolis, Minn., has 1,000,000 sq. yds. of wood block pavement, the first of which was laid in 1902. The greater part of the material is Norway pine and tamarack. The city engineer states that this pavement has required practically no repairs, the cost of same in 1911 being less than 1/10 cent per square yard. He also states that the street paved in 1902 is in good condition, and looks as if it might last for 10 years longer.

In St. Louis in 1909 repairs to 50,000 sq. yds. of wood pavement laid in 1903 cost $2.10, and in 1911 these same 50,000 sq. yds. cost less than 2/10 cent per yard, so that the total cost of repairing the 50,000 yds. of wood pavement the first nine years they were laid was 2/10 cent per yard. These pavements are all on light traffic streets.

Cleaning.—No definite information seems to be available as regards the relative cost of cleaning wood and asphalt pavements. In 1907, however, a commission was appointed by the mayor of the city of New York to investigate the entire matter of street cleaning. The following is quoted from the report of this commission:—

There is a very marked difference between the quantity of dust left upon the pavements of various kinds. Thus, if we call the average volume and weight collected from the sheet asphalt pavement 100, the relative quantities from other kinds of pavements were:

	Volume.	Weight.
From sheet asphalt	100	100
From block asphalt	130	182
From wood block (note)	332	145
From granite block	1,081	912

Note.—It should be said that the wood block pavement on which the examination was made is one of the oldest of its kind in the city, and its surface, being uneven, caught and held an unusual quantity of dust. Wood block pavement, when comparatively new, should compare favorably with asphalt block pavement in its freedom from dust retaining qualities.

After careful consideration of all the facts available, we estimate the average relative cost of cleaning, equally well, the various kinds of pavement in use in the city under similar conditions of repair, as follows:

Sheet asphalt pavement	100
Wood block pavement (new)	105
Asphalt block pavement	115
Brick pavement	120
Wood block pavement (old)	125
Medina block pavement	130
Granite block pavement	140
Belgium block pavement	150
Cobblestone pavement	3,000

On the assumption of 100 cleanings per year it may be shown that the annual cost of cleaning equally well a mile of each of the pavements named, over what it would be if sheet asphalt were substituted, would be as follows:

Wood block pavement (new)	$ 26.40
Asphalt block pavement (average condition)	79.20
Brick pavement	105.60
Wood block pavement (old)	132.60
Medina block pavement	158.40
Granite block pavement	211.20
Belgium block pavement	264.00
Cobblestone pavement	1,584.00

THE SITE OF THE MONTREAL FILTRATION PLANT.

THE board of engineers, consisting of Messrs. P. W. St. George, J. A. Jamieson and Frank A. Barbour, who were appointed by the City of Montreal at the joint request of the Board of Trade, the Canadian Manufacturers' Association and the Fire Underwriters' Association to enquire into and thoroughly examine the construction of the $5,000,000 filtration plant at Verdun, have submitted their report. In June 19th issue of *The Canadian Engineer*, the facts were given that led up to the appointment of this board. They consisted chiefly of a protest from the contractor, who alleged the site to be most unsuitable to support the heavy construction, and the design to be defective, predicting that further construction was unwise, considering the present condition. His statements were corroborated by a number of prominent engineers whose experiences with municipal installations bearing a close resemblance have been wide, and their opinions regarded authoritative.

The report, which has just been submitted to the city engineer, contains the following statements:—

Our investigation has included personal levelling by one of us to check benches and to determine the present elevation of structures, examination and measurements of the cracks and deformations now existing, studies of the design and of the very complete records prepared by the department engineers of the movements which have occurred, analyses of the soil and tests of the bearing capacity of the ground at various places under conditions, as nearly as possible, the same as those which will pertain when the plant is in operation.

The work has necessarily occupied a considerable period, largely because of the time required to move and set up apparatus, and to permit of observations of the settlement resulting from the loads imposed.

We find:—

(1) That the action of frost on the soil under foundations has been the cause, directly or indirectly, of all damage which has occurred.

(2) That settlement has not been a factor in causing damage up to the present time.

(3) That the design was good precedent, is adequate, and, if properly carried out, the resulting structure will be safe and well adapted to the intended purpose.

(4) That the soil has, and will have, under operating conditions, sufficient bearing capacity to support the loads to be imposed, and that such minor settlements as will occur, either on soil in natural position or on filled areas, will be, as shown by the tests made by us, well within the limit to which the structure may be subjected, without detrimental effect.

(5) That the design and method of construction of the arches is in accordance with good practice, and the superstructure of a type which does not require absolutely equalized foundation loads—this being indicated by the abuse which the superstructure has already withstood without serious final damage.

(6) That the walls, piers and superstructure which were raised, have now practically returned to original position, and except for some spalling of the masonry and the cracks in the division walls, will be, when the full load is on the roof, in practically as good condition as had no movement occurred.

(7) That in addition to the replacement of the damaged collectors, which has already been undertaken by the contractors, the important work necessary to return the structures to a condition practically equivalent to that which would have obtained if no movement by frost had occurred, includes the replacement or repairs of lifted floor slabs and collectors, the repairs of cracks in the division walls, gallery floor and conduit, and the replacement of the retaining wall back of the gallery walls.

(8) That the repairing, by forcing in cement grout under pressure, of structures which have been lifted from a good bearing on the soil, should, preferably, not be undertaken until after the full load to be imposed by the filling over the roof is on the supporting members, but that such grouting of space between masonry and the underlying soil should be completed before water is admitted to the filter units for any purpose.

(9) That since the raising of floors and collectors by frost has introduced abnormal conditions, it is essential that all vacant space be completely filled, or the lifted structures be replaced, and that the success of such filling of voids by grouting, as may be attempted, can only be proved by a test for leakage of the completed filter unit.

(10) That the fulfilment of such test of leakage may be accepted as proof that no damage affecting the working capacity of the filters has resulted from the movements occasioned by frost during the past winter.

We believe it necessary to recommend that, since the contract will not be completed this year, the contractor should be required to protect uncompleted work from the effects of low temperatures during the coming winter, in order to prevent a recurrence of the conditions of the past winter.

We have been greatly aided in our work by Mr. F. E. Field, resident engineer, and Mr. F. Y. Dorrance, principal assistant engineer, and by Mr. McLeod, contractor, who has co-operated in every way possible, and we desire to express our appreciation of the assistance rendered by these gentlemen, and to note the evident fairness of both these engineers and the contractor.

The structures which have already been placed by the contractor indicate good materials and workmanship, and an evident intention to fulfill the terms of the specifications, and we believe that by repair or replacement of those parts which have been damaged by frost, the work can be made entirely acceptable to the city.

The Board of Control will now decide whether the work should be continued by the contractor, or whether the city will undertake the work. Mr. McLeod has expressed his willingness to proceed with the construction, and during the six weeks in which the board of experts executed their careful investigation, he has been continuing the work on other sections of the plant.

MECHANICAL AND ELECTRICAL EQUIPMENT OF THE WINDSOR HOTEL, MONTREAL.

The power equipment for the new Windsor Hotel, designed and installed under the supervision of Mr. Kelsch, Consulting Engineer, is more complete than usual because of the problems to be met. The power plant, which is in charge of Mr. Winkworth, Chief Engineer of the Windsor Hotel Company, is one of the most up-to-date isolated power plants in Canada. The main object of the power plant is to furnish light and heat to the hotel and power for the various motors used in the laundry, for ventilating fans and in other parts of the hotel.

The steam equipment consists of three 200 H.P. Robb water tube boilers each with a heating surface of 2,143 square feet. Two of the boilers are set in a battery and one is installed singly. The boilers, which are built for 175 pounds working pressure, are equipped with Cotton blowers for burning anthracite screenings. This type of boiler consists of two horizontal cross drums with headers which are connected by a main bank of inclined tubes. The drums are connected by two rows of horizontal tubes which complete the path of circulation for the water. At the extreme top, superheating tubes connect the drums so that the steam which is separated in the front drum is thoroughly dried and slightly superheated when it enters the rear drum from which it is piped to the engines.

This boiler is distinguished from other water tube boilers by the large throat area where the front header joins the front drum giving a free and unrestricted passage for the large volume of water and steam passing from the main bank of inclined tubes into the drum. As the drums extend crosswise and the headers are as wide as the length of the drum, there is no contraction at the throat as is necessary in many types where longitudinal drums are used.

Great flexibility is another feature of this new boiler not only from the way it is placed in the setting on the supporting framework, but also because of the construction of the boiler itself. All the tube surfaces run in one direction and the plate surfaces in another, thus eliminating the strains caused in boilers where the longitudinal drums, headers, and tubes are connected rigidly together. A thoroughly modern design, this boiler has ample provision for cleaning, a handhole being placed in the header opposite each tube.

In the engine room of this power plant there are installed three Robb vertical compound engines which are run non-condensing. Each engine is direct-connected to a 150 k.w. electric generator made by the Canadian Westinghouse Company. These engines will operate the generators at 25 per cent. overload for two hours and 50 per cent. overload for one hour. With steam at 150 pounds pressure they will carry the normal load at a speed of 425 r.p.m. These engines are entirely enclosed so that working parts are protected from accident and there is no danger of oil being thrown about the engine room. Every revolving and sliding part is automatically lubricated by a system which consists of a pump and distributing pipes in which a pressure of from 10 to 20 pounds per square inch is maintained. Of the vertical type, these engines have many features which have been very successful in marine practice and modified for stationary practice enable the engines to maintain the speed desired for direct connection.

The electrical equipment had to take into account the fact that for some few years the hotel is under contract with the Montreal Light, Heat and Power Company for current, so that electrical machinery will be used only as a stand-by during this period. This situation called for especial skill in design because the Power Company operates with alternating current generators which means that the direct current switches of the hotel must remain open, except in the event of a shut down on the part of the Power Company. Should this happen the engines in the new power house will be started, the bus bars made alive therefrom and the circuit breakers and the switches on the feeders closed. Signal lamps indicate when the alternating current switches are closed and the direct current switches are open. These signals will enable the station operator to properly manipulate the switches so that the entire lighting system of the hotel will be transferred from the dead alternating current bus to the working direct current.

THE LOTSCHBERG TUNNEL.

The new Lotschberg Tunnel through the Alps was opened officially on June 20. The tunnel is the third longest in Europe, measuring over 9¾ miles, and the cost of the new line was over $17,000,000, the tunnel alone costing nearly $10,000,000. Electric traction will be used on the new route from Spiez to Domodossola, Italy. The weight of the locomotives is 112 tons, and they are fitted with two motors of 3,000 horsepower, weighing 27 tons each, the cost of construction being about $40,500, or twice that of an ordinary steam engine. The overhead or trolley system is employed, a current of 15,000 volts being carried. The locomotives are capable of pulling a train weighing 310 tons up the maximum grades of 27 per thousand at the rate of 31 miles an hour. According to the anticipations of the French press, the new railway will greatly increase the volume of trade between France and Italy, as it will bring the northern and more industrial part of France into direct communication with the peninsula. Italy lacks iron and articles made therefrom, and these have hitherto been imported through the St. Gothard Tunnel route from Germany, but the French iron works in the basin of Briey and Longwy may now be able to compete. At present the imports into Italy from Germany under this head amount to 237,000 tons annually, as compared with 17,000 tons from France.

A new Diesel oil-engine towboat of the Italian navy has a displacement of only 170 tons, but is equipped with a four-cylinder, two-cycle engine of 280 horse-power, running at 250 revolutions per minute. Compressed air at low pressure compared with that required for normal running is used for both starting and reversing. Only a few seconds are necessary for these operations, and a tank on board carries sufficient compressed air for starting or reversing sixty times.

A special bulletin has been issued by the University of Illinois Engineering Experiment Station, discussing the tests and methods employed in measuring deformations of steel and concrete in buildings. Extensive tests have been made on eight buildings in the last three years and they have shown the entire practicability of measuring deformations, or strains in critical parts of a reinforced concrete structure under load. As a direct result of the tests one company has modified its design of the floor slab adjacent to the column cap.

THE ROBB WATER TUBE BOILER.

A description of a water tube boiler that makes any pretensions to completeness would require much space, and would be uninteresting reading. Many of the details of boilers are common to practically all the makes of the water tube type. For this reason it will be only necessary to point out the difference between the Robb water tube boiler and others and explain the reasons for the improved constructions.

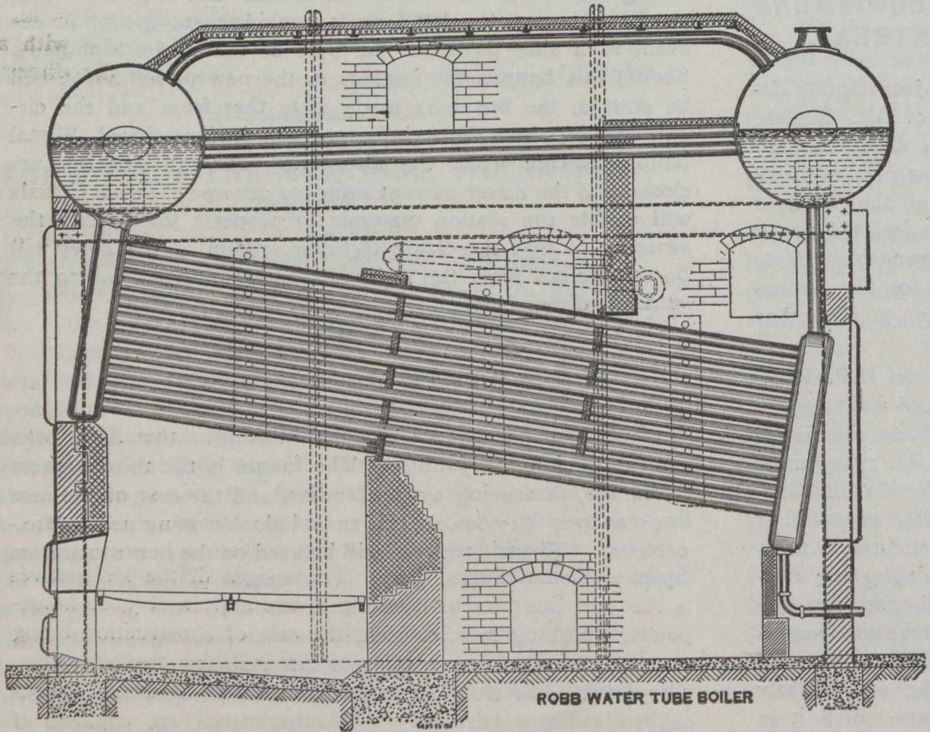

Fig. 1—Section of Robb Water Tube Boiler.

Probably the most distinctive feature of the Robb water tube boiler is the arrangement of parts to give really good circulation. This is accomplished by using two horizontal cross drums and headers, and arranging the connection between the front header and the front drum so that there is an abundantly large passage for the mixture of water and steam as it rises from the tubes just over the hottest part of the fire.

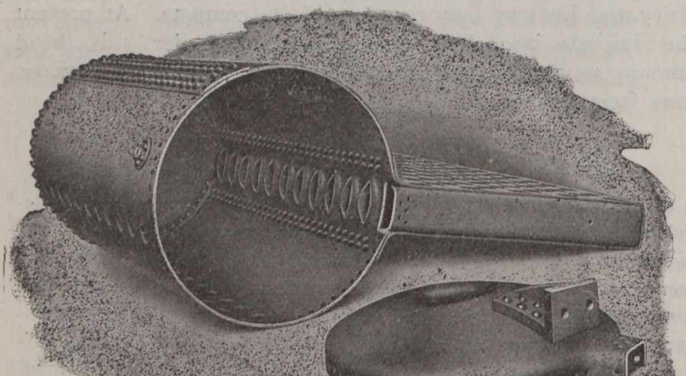

Fig. 2—Showing Construction of Front Drum.

With this construction it is not necessary that the mixture of steam and water pass through a small passage or a single tube for it has the large area provided by the header which extends the entire length of the front drum. By means of a patented throat connection this large passage is obtained without weakening the shell of the drum.

The circuit of the water is completed by connecting the two drums with a double row of horizontal tubes at the water line and by joining the rear header to the rear drum by a row of vertical tubes. This row of vertical tubes at the rear has abundant area for the passage of the water for at this point the water only must be provided for, whereas, at the front of the boiler a larger volume, a mixture of steam and water, must be taken care of.

Flexibility is another feature which has received much attention in the design of this boiler. Flexibility is closely allied to expansion and contraction. In order that such strains may be an absolute minimum in the above type of boiler, all the tube surfaces run in one direction and all the plate surfaces in another, thus avoiding the disastrous results often experienced from unequal expansion and contraction between thin tubes and thick drum plates when both run lengthwise and are connected rigidly.

The boiler is carried on a steel framework entirely independent of the brickwork. The front drum is the only part that is fixed in position. The rear drum is supported by brackets resting on rolls and the rear header is suspended by the long vertical tubes which connect the rear header and the rear drum. It is, therefore, free to swing back and forth and take care of the expansion and contraction of the main bank of tubes.

Dry steam is assured at all times, because the steam is not taken from the same drum in which it is separated from the water. The mixture of water and steam in this type of boiler enters the front drum, the steam separating out passing through the superheating tubes at the extreme top to the rear drum from which it is taken to the steam mains. The water which separates from the mixture flows to the rear drum through the horizontal tubes and mixes with the cooler entering feed water.

One other point is worthy of notice; that is, the arrangement for cleaning the inside of the tubes. The water

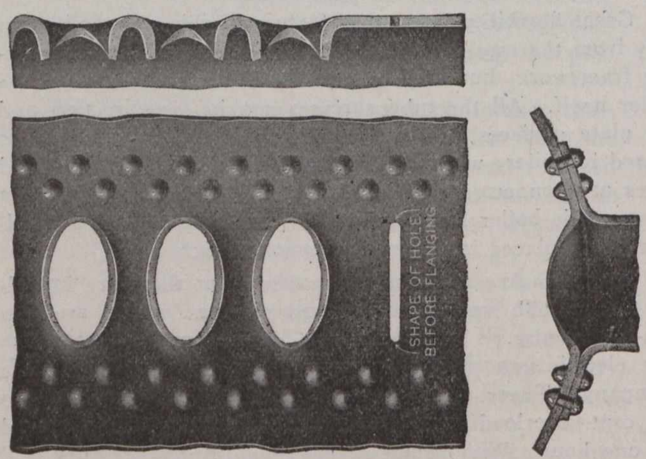

Fig. 3—Showing Throat Connection to Front Drum.

tubes are absolutely straight, as water tubes should always be, and to clean them it is only necessary to remove the front hand-hole plate opposite a tube, insert a scraper and push the sediment back into the rear header from which it drops into the mud chamber at the bottom. The hand-hole plates are oval and there is one opposite each tube. This greatly increases the convenience in cleaning over those boilers having round hand-hole plates, which require that they be worked hand-over-hand amongst the stay bolts.

In all respects the new Robb water tube boiler, which is made by the International Engineering Works, Ltd., fulfils the requirements of the rules formulated by inspection and insurance companies and government officials. Although rated at 10 square feet of heating surface per boiler H.P., they have proved under severe tests to have a capacity 50 to 100 per cent. over rating without injury.

AMERICAN ROAD CONGRESS IN DETROIT.

How to systematize the purchase of road equipment and materials will be explained in a paper to be read by Henry G. Shirley, chief engineer of the Maryland State Roads Commission, at the American Road Congress which will be in session during the week of September 29 at Detroit, Michigan. This paper deals with one of the many important subjects to be treated by experienced engineers, public officials and road contractors at the big meeting. On account of the fact that the Maryland Commission has been working out the problems of good road administration in a most painstaking and thorough manner, Mr. Shirley's paper should be a most welcome contribution.

Col. E. A. Stevens, state highway commissioner of New Jersey, will have a paper at the Congress on treatment which he has found most effective for worn out or raveled macadam surfaces. New Jersey was the first State to adopt the State aid plan for road construction and consequently had a large mileage of water bound macadam roads prior to the advent of the motor vehicle. The problem of the State highway department has therefore been particularly along the lines of adopting the old roads to new traffic conditions.

The merit system in road administration will be aptly presented in an address by President John A. McIlhenny of the United States Civil Service Commission and will undoubtedly attract nation wide attention as it is a notorious fact that political favoritism and indifference characterize the administration of our public roads so generally as to cause a loss estimated by some experts as high as $40,000,000 a year. No more serious drawback to the progress of road improvement exists than the incompetent management of the roads and it is hoped that Mr. McIlhenny's address will help in securing much-needed reforms.

Other addresses and papers will be given by Capt. P. St. J. Wilson, State Highway Commissioner of Virginia; W. S. Keller, State Highway Engineer of Alabama; A. R. Hirst, State Highway Engineer of Wisconsin; Frank F. Rogers, State Highway Commissioner of Michigan; and many others prominent in the practical field of road construction and maintenance.

The Congress is held under the presidency of Logan Waller Page, director of the United States Office of Public Roads and comprises the conventions of the American Highway Association, the American Automobile Association, the Michigan State Good Roads Association, a large session under the auspices of a committee from the American Bar Association and other special sessions held under the auspices of the leading organizations identified with the road movement. The attendance at the first congress held in Richmond, Virginia, 1911 was 1,200; at the second congress held at Atlantic City in 1912, 2,000. This year the ratio of increase will be supplemented by an attendance of at least 2,000 at the State Good Roads Association, so that the management conservatively estimates the attendance this year will be over 5,000 delegates and members.

The National Association of Road Material and Machinery Manufacturers will be represented by a great commercial exhibit of road machinery and materials and arrangements have already been made for an exhibit of the remarkable collection of road models owned by the United States Office of Public Roads and for interesting exhibits by many of the States, cities and educational institutions.

MAINTENANCE OF PURE WATER IN SASKATCHEWAN BY PROVINCIAL BUREAU OF HEALTH.

As the present excessive death rate from typhoid fever in Canada is admittedly due to neglect in protecting surface waters from pollution, it may be interesting to record what measures are being adopted by the Saskatchewan government, through the Bureau of Public Health, towards the conservation of the purity of provincial waterways.

The Bureau of Health has continued to impress on all municipalities the grave lesson to be learned from the lack of foresight of older communities, and the towns and cities have been quick to realize that a system of sewerage is not a convenience but a sanitary necessity, and that the very object aimed at in its installation, namely, the protection of the public health, may be defeated if some efficient treatment is not provided to render the effluent incapable of supporting the germs of disease.

As a result of this policy, there are at present eight sewage disposal plants in operation in Saskatchewan. In seven of these installations, the sewage is treated by biological filtration, in addition to sedimentation, and a filter is being added to the remaining plant this year. Further, plans for ten additional sewage disposal installations for various towns have been submitted to the Bureau, and these works should be in commission before the end of the year.

This means that at the close of the present year the sewage from all the cities and thirteen towns in the province, representing about one-third of the total population, will be rendered practically harmless before being discharged into the water courses. When it is considered that in 1912 there were only five sewage disposal plants in operation, capable of treating sewage from a population of 16,500, it must be evident that municipalities are co-operating with the Bureau of Health in the improvement of the condition of provincial waterways.

Systematic supervision and inspection is made of the existing sewage disposal works by the engineering officials of the Bureau, and suggestions offered, which are calculated to give a higher standard of efficiency in each new installation. The Bureau of health has, up to the present, concentrated its efforts in the prevention of stream pollution by municipalities, but now that the towns and villages are alive to the consequences of neglect in matters of sewage treatment, it is the intention of the officials to direct their energies towards the large section of the population who, individually rather than collectively, contaminate surface water supplies. There are numerous settlements, camps and villages along the streams and creeks, which have no system of disposing of their sewage, but simply use the nearest watercourse as a common sewer. Such streams being subject to direct pollution from fecal matter entering the water from isolated houses or camps, are capable of carrying disease through the large areas of the province which they traverse, and is largely responsible for the outbreaks of typhoid which have occurred in the province. The possibility of some such direct pollution being present in a river, which is supplying unfiltered water to one of the larger towns, is only one instance of the viligant guard which must be kept over the streams. With this in view, the Bureau of Health is about to commence a thorough and exhaustive inspection of the various watercourses throughout the province.

If immunity from typhoid is to be aimed at in Saskatchewan, all possible sources of domestic water supply must be under constant supervision, and this can only be accomplished by making a systematic survey of the entire province.

There are two periods in the history common to all rivers which serve as a source of water supply for the populated districts through which they flow. First, that of gradually increasing pollution from domestic sewage and trade wastes, which, unnoticed, continues to render the water dangerous, until a severe outbreak of typhoid fever is reported at some point down stream, involving the loss of perhaps scores of lives. Then follows a period of investigation into the source of contamination, and legislation to prohibit further pollution of the river in question. This history has repeated itself in practically every civilized country, and at the present time a bill is receiving its second reading at Ottawa, the object of which is to prohibit further pollution of Dominion waterways. A special committee has been elected to report on the subject. Further, the Commission on Conservation is making careful inquiry into the question of stream pollution, and inviting the provincial authorities to co-operate in safeguarding the public health. A third commission is seeking to solve the problem from an international standpoint.

It is to be regretted that several outbreaks of typhoid fever, accompanied by many deaths, should have been necessary to awaken general interest in the increasing pollution of our rivers and streams. Generally speaking, it is an accepted fact that the typhoid death rate of any country may be taken as the index for the condition of its streams and rivers.

The average death rates from typhoid fever in Norway, Sweden, Holland, Germany, Switzerland and Great Britain vary from 6.2 to 12.8 per 100,000 of the population. In Canada the typhoid death rate is 35.5. Unfortunately, the province of Saskatchewan has contributed in a large measure to this high death rate for the Dominion. Within recent years outbreaks of typhoid fever have occurred at Moose Jaw, Saskatoon and Prince Albert. The number of cases in Regina has never been so great as in the other cities. This fact is significant when it is considered that Regina receives its water supply from underground sources.

Conditions have greatly improved within the last few years, however, and the death rate from typhoid fever in the province should show a marked decrease this year. Saskatoon and Prince Albert have both installed efficient filtration plants, and Moose Jaw has abandoned a surface supply in favor of water from springs at Caron, the construction and plant of whose system was dealt with in *The Canadian Engineer* for March 6th, 1913.

A NEW ROAD MATERIAL.

With a view of obtaining a road surface which will give a better resistance to automobile traffic, experiments are being made again in France with a road-bed material consisting of a mixture of "iron straw," or iron in the shape of a wiry or fibrous mass, together with cement mortar and sand. Such material is called "ferro-cement," and it appears from tests that it is giving good results. The iron is specially prepared by suitable machines, and it is claimed that the resulting material is not over-expensive.

COAST TO COAST.

Regina, Sask.—The parks and playgrounds committee of the Town Planning Association are endeavoring to have more playgrounds established in the city, with the required equipment. The city of Regina has already spent thousands of dollars on this work.

Ottawa, Ont.—Preparations are being made to commence immediately the extension of the refinery at the Dominion Mint. A vote of $40,000 for that purpose was passed last session, as the refining of Canadian gold has gradually increased, and made necessary an extension of the present refinery. Last year the amount of Canadian gold was $1,168,-823. Government architects will have charge of the work.

Toronto, Ont.—The proposal to use the Niagara River from Lake Ontario to a point near Queenston in connection with a new Welland Canal, which would be built from that point to a Lake Erie outlet, was presented before the Toronto Harbor Board recently by Ald. L. Pitt, of Niagara Falls, Ont., who is behind the project. Should this plan be adopted it is claimed that about $30,000,000 would be saved over the cost of the new Welland Canal proposed by the Government. Ald. Pitt, after showing the plans to the harbor board, stated that it was his intention to at once lay the question before Hon. Frank Cochrane, Minister of Railways and Canals.

Ottawa, Ont.—The Department of Public Works is investigating the utility of railway marine docks. Mr. Arthur St. Laurent, Assistant Deputy Minister of Public Works, has returned from Boston, where he inspected the Crandall engineering works, makers of this style of docks. For vessels or steamers up to 10,000 tons they are well suited, the ship entering a cradle and being quickly drawn up high and dry by an engine. The average cost is about $60,000, and as many as four vessels can be accommodated at once. Mr. St. Laurent was favorably impressed, and will recommend the railway docks for places where it is not desirable to go to the heavy expense of a graving or floating dock.

Ottawa, Ont.—Either the increase in population of the city, consequently causing an increased demand, or the percentage of waste has abnormally increased, is the reason for the high average of the water consumption reached this year. Acting Waterworks Engineer Wm. Storrie has reported to the waterworks committee that the average daily consumption last year was 17.7 million gallons daily, while so far the average this year has touched 18.6 million gallons per day. The figures this year for maximum million gallons daily are: January, 19.6; February, 19.7; March, 20.2; April, 19.1; May, 19.4; June, 20.0; July, to date, 21.5. The work on the pitometer survey for the detection of wastes is going ahead satisfactorily, and a number of small leaks have been detected and quickly repaired.

Vancouver, B.C.—Advertisements calling for tenders for the new dock to be built at Vancouver by the Dominion Government have been sent out and plans and specifications are being mailed to this city. Information to this effect was received recently by Mr. H. H. Stevens, M.P., in a telegram from Mr. J. B. Hunter, Deputy Minister of Public Works, Ottawa. The Government wharf will be located at the foot of Salsbury Drive, and will cost about $750,000. Construction work will probably start about the middle of next month, and the work is expected to take twelve months. The dock will be approximately 1,000 feet in length and 300 feet wide, with three railway tracks in the centre and concrete retaining walls on each side. The lowest depth of water at the land end of the dock will be thirty-five feet, thus enabling vessels of large draft to berth at all stages of the tide. A large number of tenders are expected to be submitted, as the contracts are open to the world.

Windsor, Ont.—"Think of how few persons in the United States will be benefited by the Panama Canal, on which we are spending $420,000,000, and then consider the great benefits to be derived by the hundreds of thousands of people clean across the country from the Lincoln Highway, stretching from the Atlantic to the Pacific," said E. P. Brinegar, secretary of the Argonaut Trail Committee, of San Francisco, in Detroit recently. The Argonaut Trail Committee is the dynamic California force in the western movement that is aiding the ocean-to-ocean project as a memorial to Abraham Lincoln, and fostered by the Lincoln Highway Association. "The Panama Canal, for which every citizen must pay his share of the cost, will bring untold benefits to England and Europe, enabling commercial interests there to gain easy access to the Orient," Mr. Brinegar continued. "It will make it easy for Atlantic coast shippers to reach the Pacific coast, and vice versa. But will it help the people of Michigan, Ohio, Indiana, Iowa or any point in the middle or far west? Yet the Lincoln Highway, of which our own Argonaut Trail, we hope, will be a part, will pass the front door of uncounted multitudes of people, and will be perpetually at their service. An ocean-to-ocean road built for endurance is a national need. There are men in Nevada and in other States to-day who must haul water fifty miles over rough and burning trails. And in States far more opened to civilization the need is equally great."

Vancouver, B.C.—Many roads about Greater Vancouver are being opened, cleared and graded and put in shape for traffic by the Provincial Government, under the supervision of Provincial Road Superintendent, Mr. E. McBride. The Provincial Government has appropriated $25,000 to the municipality of West Vancouver for the improving of Marine Drive within its boundaries. To connect with the improved thoroughfare in the new municipality the Government is having Robson Road, from the west boundary of the city of North Vancouver to Capilano Creek, cleared and graded and put in good condition for all kinds of vehicular traffic. When all the roads on the north shore now in course of repair and improvement are finished, Road Superintendent McBride says that the districts on the north shore of the inlet will have excellent highways; in fact, nowhere in the province will there be better roads, and the scenery along the whole route from the North Arm to Howe Sound will be an attraction to tourists and others. Mr. McBride has charge of all road work in the Westminster district as far up the coast as Pender Harbor. In the district bordering this arm of the gulf much work is also being done by the Government in improving the roads. Mr. McBride in his periodical trips of inspection superintends all construction work. In numbers of cases after the roads have been cleared and graded the municipalities macadamize the surface and in other ways treat the portion of the roads which are most used for traffic.

Ottawa, Ont.—The Government is reported to be about to appoint a water power commission to be known as the St. Lawrence and Great Lakes Commission, for the purpose of studying the whole question of water power development from the head of the Great Lakes to Montreal. The probable members of the commission are given as: Professor McLeod, McGill University; Mr. Arthur Surveyer, Montreal; and Mr. C. R. Coutlee, of the Public Works engineering staff. It is expected the St. Lawrence and Great Lakes Commission will be engaged upon its task for several years to come. This work may result in the establishment of a permanent bureau dealing with water power questions to which the Government can go for reference. The Canadian section of the International Waterways Commission will have the use of the reports of the new commission.

Vancouver, B.C.—On a general inspection trip of Western lines of the Canadian Pacific Railway system, Mr. J. G. Sullivan, chief engineer for Western lines, arrived in the city recently. The question of utilizing oil as fuel instead of coal, as at present used on locomotives on the Cascade division of the Canadian Pacific Railway main line between Vancouver and North Bend, is one of the principal subjects to be taken up by the chief engineer with local traffic officials. Oil is used as fuel on other sections of the line in British Columbia, and an extension of the use has been planned in accordance with the general policy of increasing the efficiency of the service. Tanks for the fuel have been located at Port Moody, and the idea was mooted some time ago of having the oil piped to Coquitlam, where the Canadian Pacific Railway shops are now established. Mr. F. F. Busteed, engineer in charge of the double-track operations in British Columbia, accompanied Mr. Sullivan to the city from Kamloops, and will take up a number of questions with him before he leaves again for the East. Mr. F. W. Peters, general superintendent for the British Columbia division, and Mr. H. Rindal, district engineer, will accompany Mr. Sullivan on his inspection trip of the main line and branches in this Province next week. The various terminal improvement schemes, in the way of new docks, bridges and new depot, which are now being actively prosecuted by the Canadian Pacific Railway in Vancouver, will be inspected by the chief engineer, and he will also discuss the gigantic tunnel scheme in the vicinity of Rogers Pass with local officials.

Victoria, B.C.—Just what shall be done towards putting an end to harbor pollution, a subject on which there has been of late numerous suggestions made to the city council, is a question which has been under investigation by the health officials of the city. City Sanitary Inspector Lancaster has, as a result of his investigations, reported to the medical health officer to the effect that the chief source of trouble is from sewerage effluent from various vessels berthing at the wharves, and for this he can suggest no remedy. Another serious phase of the question is the dumping into the harbor, from vessels, of garbage, kitchen refuse, boxes ,etc., This can be remedied if those in charge of the vessels would insist that the rubbish now regularly deposited in the harbor be retained until the ships are well at sea. What can be done relative to the obnoxious odors which arise when the tide is out is another matter to be dealt with. The disagreeable odor arising from the mud flats below the Causeway during low water can apparently only be obviated by the dredging out of these banks so that at low water there will still be water over the mud. Whether the retaining walls now there would be affected if the present flats were dredged is a question which would have to be investigated. Either dredging would have to be resorted to or a smaller and lighter wall built some distance from the present walls and the space between filled in. Medical Health Officer Hall will shortly have a report before the city council going into the whole matter, and will make certain recommendations for the council's consideration.

Ottawa, Ont.—Experiments are to be made by Controller Nelson and Engineer Currie in the use of tarvia and oil on roads instead of water sprinkling. While the work this year will not be carried on in an extensive scale, it will form the basis of a report for next year's city council. It is estimated that the macadam and ordinary dirt streets can be treated with tarvia or oil for about ten thousand dollars more than the street sprinkling costs this year. The advantage of the extra expenditure will be more satisfactory work, and in addition it is claimed the oil and tarvia will pay the extra cost in added life of the roadway and lessened repairs. So far, tarvia, oil and similar substances have not been used to any extent by any city on asphalt pavements, and it is not proposed to experiment with them here. Water would still be used, but instead of the present sprinkling carts, up-to-date flush tanks are proposed. Controller Nelson intends to shortly visit Detroit and Rochester to inspect the kind of streets they have there and the methods of treating them.

Montreal, Que.—Councillor W. G. M. Shepherd, of Westmount, has returned from an extensive road tour of New York and the New England States, in which he was the guest of Lorne Webster. Mr. Johnson, of the Department of Marine and Fisheries, accompanied the party. "American roads certainly show a vast improvement on Canadian ones," stated Mr. Shepherd. "Our trip, which was from Ogdensburg to Kennebunk Beach, Me., included an itinerary of nearly five hundred miles; and the worst part of all this stretch was much better than the majority of the roads around Montreal. In my opinion we are losing thousands of dollars every year in American tourists alone by our lack of automobile roads fit to run a car over. The fact that the highways bill lost out in the Senate should not prevent the Provincial Government from building a highway, say, from Montreal to Quebec. Nothing would advertise our province so well."

Toronto, Ont.—"United States Government aid will mean railroad construction to the extent of upward of one thousand miles," declares Falcon Josleyn, of Fairbanks, in a hearing on the Alaska Railroad bill before the house committee at Washington on territories. The Canadian Government is building the Grand Trunk Pacific across the continent to the Pacific Ocean through a country not nearly so productive or rich as Alaska for a distance of more than three thousand miles, and we are here to ask Congress to authorize the construction of only a little more than seven hundred miles of road. Our territory needs railroads for development of its natural resources, and we ask favorable action on our bill." Mr. Josleyn gave the committee detailed information about mineral and agricultural resources of Alaska, and also some information about the poor transportation facilities. The committee appeared impressed with his testimony, and questions asked indicated a disposition to help railroad construction in the territory.

PERSONAL.

Mr. E. J. WHITTAKER, of Seaforth, Ont., has received an appointment to the palœontological staff in the geological surveys branch of the Department of Mines, Ottawa.

Mr. T. BROCKMAN, landscape architect, of Berlin, presented an address on the subject of "Town Planning" to a recent meeting of the Regina Engineering Society.

Hon. FRANK COCHRANE, Minister of Railways and Canals, is on a tour of inspection of the Trent Canal. He is accompanied by W. A. BOWDEN, B.A.Sc., chief engineer for the department.

Professor S. A. MITCHELL has been appointed director of the Leander McCormick Observatory at the University of Virginia. Graduating from Queen's University in 1894, he secured a gold medal in chemistry for his spectacular attainments in research work. He has for some years held a professorship in Columbia University, New York.

Mr. C. W. GENNET, Jr., has assumed the duties of treasurer and manager of the Messrs. Robert W. Hunt & Company, Limited, at their principal office in the McGill Building, Montreal. Mr. Gennet has heretofore been in charge of the parent company's bureau of inspection of rails and fastenings at the home office in Chicago.

ARTHUR H. BLANCHARD, M. Can. Soc. C.E., Professor of Highway Engineering in Columbia University, has returned from Europe, where he attended the London Congress of the Permanent International Association of Road Congresses as a delegate from the State of New York and several societies. After the adjournment of the Congress Professor Blanchard made an investigation of various pavements and roads in England, France and Germany.

OBITUARY.

Mr. J. H. New, of Toronto, for many years president and managing director of the Hamilton and Toronto Sewer Pipe Company, died on July 17th after an illness of several weeks' duration. Mr. New had many business interests in the city and was long associated with manufacturing activities in Toronto and Hamilton.

Mr. N. G. H. Burnham, in charge of one of the sections of the Manitoba branch of the Hydrographic Survey of Canada, was drowned in the Valley River, near Dauphin, Manitoba, on July 15th, through the capsizing of a canoe. Mr. Burnham and his party were attempting to make a particularly difficult crossing at the juncture of two streams when the accident occurred. The unfortunate young engineer was a son of Dr. G. H. Burnham, of Toronto. He matriculated from Upper Canada College into the Royal Military College, Kingston, in 1906. On the completion of his course in the Royal Military College, in 1909, he entered the faculty of applied science at Toronto University, graduating with the degree of B.A.Sc. in 1912. For the past year and a half he has been engaged in hydrographic survey work in Manitoba and Saskatchewan.

COMING MEETINGS.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—The Twelfth Annual Meeting to be held in Canada during July and August. Opening day of the Toronto Session, Thursday, August 7th. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa.

THE ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Sixth General Annual Assembly will be held at Calgary, Alberta, September 15th and 16th. President, J. H. G. Russell, Winnipeg, Man.; Honorary Secretary, Alcide Chaussé, 5 Beaver Hall Square, Montreal, Que .

A joint annual meeting of the Canadian and American Peat Societies will be held at Montreal, Canada, on August 18th, 19th and 20th, 1913.

The first International Exposition of Safety and Sanitation ever held in America will take place in New York City, December 11th to 20th, 1913, under the auspices of the American Museum of Safety. Safety and health in every branch of American industrial life, manufacturing, trade, transportation on land and sea, business, engineering, in all of their sub-divisions will be represented at this exposition. It will be the first step toward making a representative exhibition of the progress of safety and preventive methods in America.

READERS SHOULD NOTE THE REMOVAL OF THE LIST OF CANADIAN TECHNICAL AND MUNICIPAL SOCIETIES FROM THIS PAGE TO PAGE 94, IN THE REFERENCE SECTION OF **THE CANADIAN ENGINEER.** BY THIS CHANGE, ALMOST AN ENTIRE PAGE OF READING MATTER IS ADDED WEEKLY.