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QUAKER OATS FIRE WRECKS FLAT-SLAB WAREHOUSE

T. D. MYLREA, ASSISTANT TO THE CITY ARCHITECT OF TORONTO, INVESTIGATES COLLAPSE OF REINFORCED CONCRETE BUILDING AT PETERBOROUGH AND REPORTS THAT STRUCTURE IS COMPLETELY RUINED OWING TO EXTREMELY HIGH TEMPERATURES MAINTAINED FOR UNUSUAL PERIOD—CITY ARCHITECT SAYS IMPOSSIBLE FOR ANY MATERIAL TO RESIST FIRE OF SUCH INTENSITY AND DURATION

T. D. MYLREA, engineer in charge of tests for the city architect's department, Toronto, has made a report on the destruction of the flat-slab type, reinforced concrete warehouse at the Quaker Oats fire, which occurred December 11th, 1916, at Peterborough, Ont.

As thirteen buildings of the flat-slab type were erected or started in Toronto during 1916 (with a permit value of $1,872,000), W. W. Pearse, the city architect and superintendent of building, was naturally anxious regarding the fireproof qualities of the flat-slab type of construction, in case any serious deficiency in that type of construction should have been shown by the Peterborough fire. Mr. Pearse states the flat slab type of construction was recognized in a building by-law by the city of Chicago in 1914, which was the first time that type of construction had been officially recognized in any city by-law, so far as he is aware. The fact that this recognition was so recent, increased Mr. Pearse's anxiety to know the full facts in regard to the failure at Peterborough, which was undoubtedly the worst of its kind in the history of reinforced concrete construction, and the first in the history of this particular type of reinforced concrete design.

Fig. 1—General View of Quaker Oats Plant Before Fire.

Mr. Mylrea's report, which is thorough and exhaustive, and which is accompanied by a number of plates and fifty-two photographs, proves conclusively that the Peterborough fire was a most unusual one, presenting conditions not likely to be duplicated very often, *viz.*:—

(1) The fire raged simultaneously on all seven floors (including basement) of the building.

(2) The oats and feed, which were piled high on each floor, burned fiercely but slowly, retaining a very high heat for a long period. They produced the effect of an intense coke fire.

(3) The fire raged in full blast for seven hours before any part of the building fell.

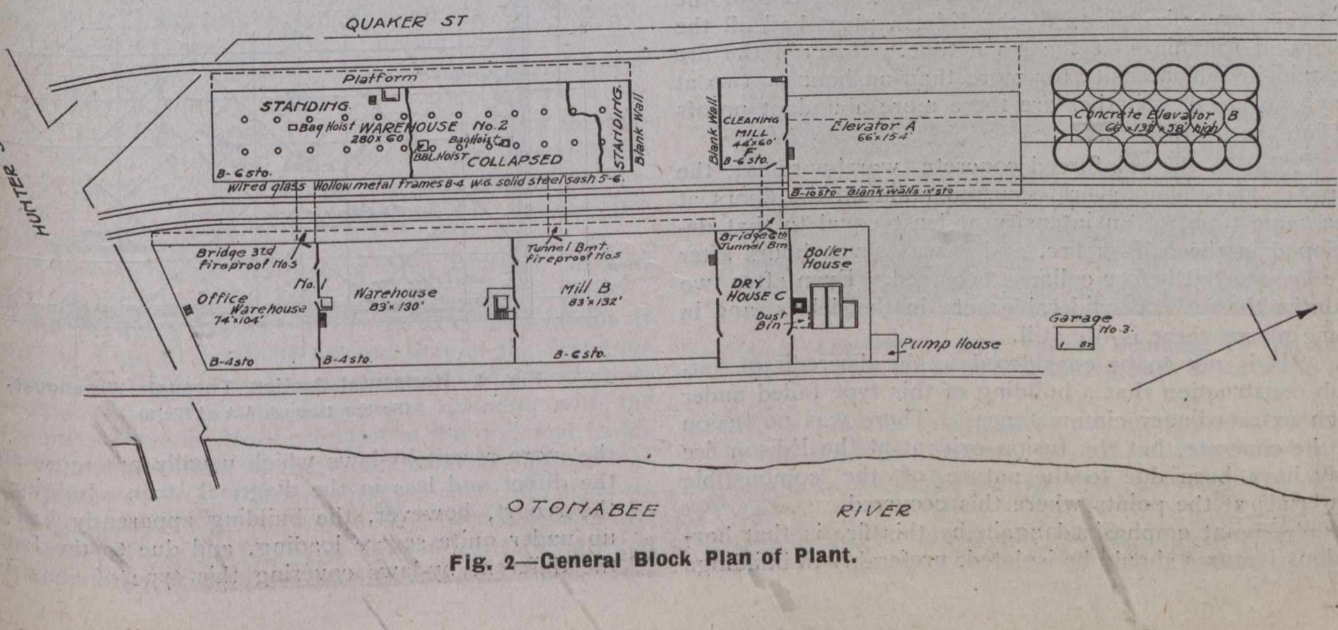

Fig. 2—General Block Plan of Plant.

Mr. Mylrea's conclusions are as follows:—

Mr. Mylrea's Conclusions.—"The first lesson to be drawn from this conflagration is that absolutely 'fireproof' construction is a chimera, for if heat is sufficiently intense and long-enduring, no material can withstand it. This fact has been demonstrated in fires upon practically all the materials of 'fireproof' construction, and now the latest type of building succumbs to it.

"The fact that concrete stood so well in the Edison fire has been hailed far and wide, and the severity of that fire was so great that it has become somewhat of a criterion of fire intensity. It seems almost sacrilige to say that at the Quaker Oats fire, we had a more severe fire than at the Edison plant. Yet, in the press of the time cuts were printed which show that not one of the large concrete buildings of the Edison plant had all the floors in full blaze at the same time. Nor did the fire remain in full intensity for more than an hour or two at any one place. Neither are there more abundant proofs of intense heat.

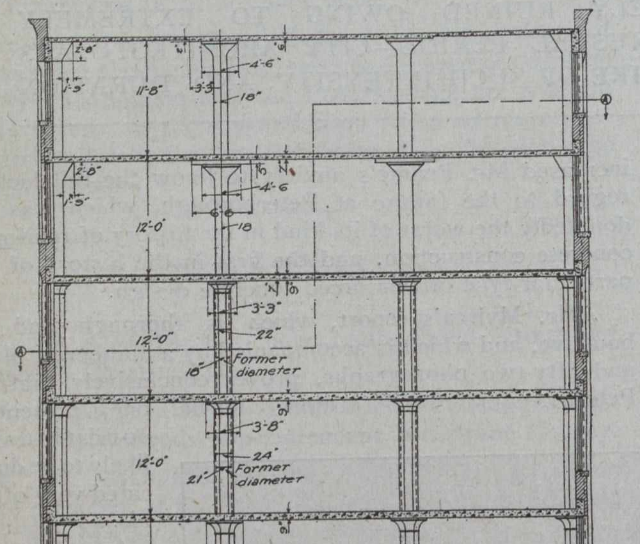

Fig. 3—Typical Cross-Section of Concrete Warehouse.

"But in the reinforced concrete warehouse at the Quaker Oats plant a fire occurred upon all the floors at the same time, of an intensity at least equal to that developed in the Edison fire, and it was seven hours after the fire started before collapse occurred. Even after two months there is considerable heat in the debris, and in some places there is fire still.

"It is not to be considered to the discredit of flat-slab construction that a building of this type failed under such extraordinary circumstances. There was no fusion of the concrete, but the fusion evident at the Edison fire may have been due to the nature of the combustible materials at the points where this occurred.

"A point emphasized again by this fire is that hazardous features should be isolated, preferably in buildings with large window areas. In this case the large blank wall areas of the dry-house tended to hold the pressure. Consequently, not only were the walls wrecked but the fire was flung far into the mill. In several small explosions in Toronto, wired glass has had the effect of holding the pressure, with consequent damage to walls, so the window areas recommended should preferably be glazed with plain glass.

"As far as the matter of fireproofing is concerned, if a fire is of sufficient intensity to heat a nine-inch floor slab through, it is evident that four and one-half inches of fireproofing would avail nothing. Moreover, if it is merely covered with mortar, the reinforcing will not oxidize. In the usual design of flat slab, the steel is not stressed to more than about one-third of its elastic limit under design load, so it could readily stand a temporary reduction in strength of 50%. This would correspond to a rise in temperature of about 1,250° F., at which temperature the cement in the concrete would be completely dehydrated. There is nothing to be gained, therefore, by excessive fireproofing of the rods."

Mr. Pearse's Conclusions.—In an interview concerning Mr. Mylrea's report, Mr. Pearse said:—

"In my opinion, it would be impossible at the present time to erect any building that could resist a fire of the magnitude and duration to which this building was subjected.

"The building apparently was constructed in what is known as the 4-way reinforced concrete type of construction. It will be noted that on the first four floors there were no drop panels at the columns, and also that there was more steel put in the diagonal than there was in the straight or direct strip. This is not in accordance with the more recent by-laws which usually put more steel in the direct and less in the diagonal strip. Judging from the report, however, the building apparently had stood up under quite severe loading, and due to the fact that the different by-laws covering this type of construction

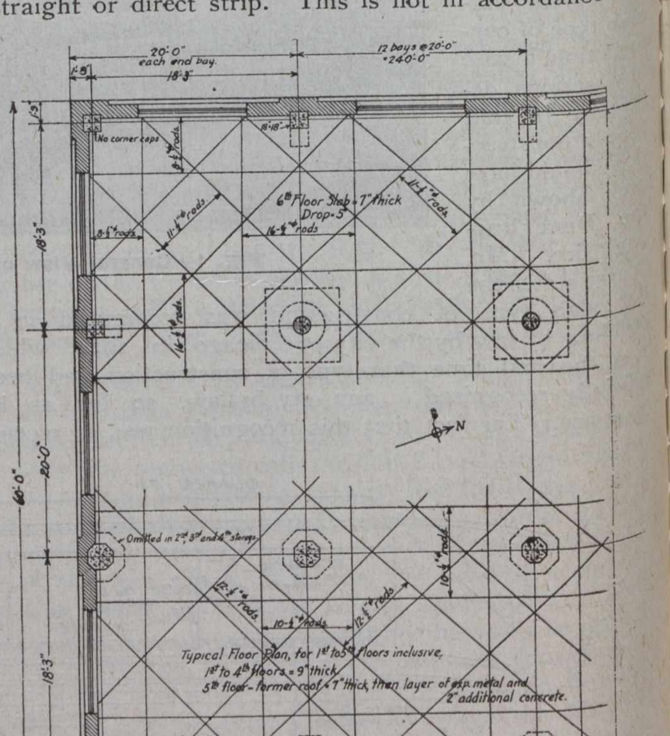

Fig. 4—Horizontal Section Through Warehouse.
(Section through A-A of Fig. 3)

vary as much as 100 per cent., it seems out of order at the present time to pass any criticism on the way this building was designed."

Fig. 1 is a general view of the plant, all of which was of brick or mill construction, with the exception of the one warehouse which was flat-slab type, reinforced concrete construction, and the circular concrete grain bins,

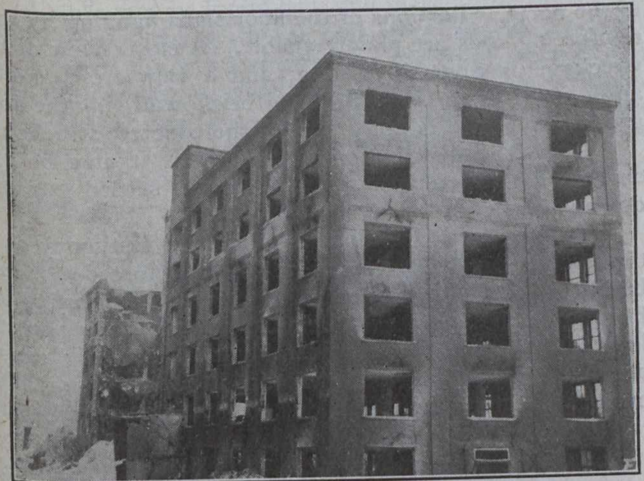

Fig. 5—The Warehouse After the Fire.

which were of reinforced concrete construction. The grain bins are at the extreme right of the plant, the concrete warehouse at the extreme left, in the rear of Fig. 1, running from the left end of the plant almost to the wooden elevator building on which there was a large "Quaker Oats" sign, and paralleling the mill construction building which burned first and which set fire to the contents of the concrete structure.

The eighteen storage bins were practically uninjured by fire, and represent the only portion of the plant which is not an absolute wreck. Fig. 2 is a general block plan of the plant. The portion of the concrete warehouse which collapsed is indicated, but the remainder of the warehouse is gradually breaking up and is so badly injured that it will be torn down, says Mr. Mylrea.

Fig. 3 gives a typical cross-section of the reinforced concrete warehouse showing the general constructional features. Fig. 4 is a horizontal section showing the kind and amount of reinforcing on the various floors.

The concrete warehouse was approximately 60 ft. wide, 280 ft. long and basement and six stories high. The Leonard Construction Co., Limited, were the engineers and contractors for both the upper and lower sections of the building.

The first four stories were build in 1910 and the two upper ones in 1916, and the common practice at these different dates is well represented in the details of construction. The floors were designed for 200 lbs. per square foot, live load.

Following is an abstract of Mr. Mylrea's detailed report:—

Mr. Mylrea's Report.—From the structural details as shown in Fig. 3, it will be noticed that in the first four stories there are no drop panels at the top of the columns, and that the column caps decrease in diameter with the columns. There is also more steel in the diagonal bands of reinforcement than in the direct bands. The circular reinforcement of the column shafts consist of separate steel hoops about 1½ ins. x ¼ in. in section spaced about 8-in. centres. As the theory of flat-slab construction was not understood at the time these stories were built, these are features that contradict the facts brought out later by extensometer tests, but they represent the best construction known at the time.

The upper two floors show the column capital of constant diameter, the drop panel, the correct distribution of the slab steel, and the spiral form of circular column reinforcement. For some reason or other, the drop panels were omitted from around the caps of the wall columns in the two upper stories and a bracket substituted. On the corner columns even these brackets are lacking.

Since a drop panel would not have interfered with with the windows, it is hard to tell just why this was done, for at these places the bending moments are most severe. It might have been that the type of construction adopted required less work on the forms. It might be fair to state, however, that up until quite recently another American firm had this bracket system as one of its standards, in which case they used four brackets around the interior columns, and no flaring heads.

When the two upper stories were erected, it was decided to increase the diameter of the columns on the third and fourth stories to aid them in carrying the additional load. This was accomplished by wrapping them in expanded metal and pouring a rich grout around them. The fifth floor—the former roof—was increased from 7

Fig. 6—Looking Directly Toward Standing 1⅓ Bays to the north. View taken from Standing Bays at the south end.

ins. to 9 ins. in thickness by laying expanded metal upon it and pouring another 2 ins. of concrete on it. The aggregate used throughout was a local gravel of good quality.

The north wall of the building was blank. The east wall, facing the lane between the reinforced concrete building and warehouse No. 1, had a large number of windows with metal sash and wired glass. The sash and frames in the first four stories were of hollow metal, and in the upper two stories were of solid metal. On the other two sides of the building ordinary wooden frames and sash were used, with the exception of the north bay on the west side, which was the same as on the east side.

All the buildings, with the exception of the concrete warehouse and the concrete grain bins of elevator B, were equipped with automatic sprinklers. All the buildings,

Fig. 7—A "Close-Up" of the Wreck.

with the exception of the circular grain bins, are now in ruins. The lower 15 feet of two of the tanks was somewhat spalled and on the easterly of these two tanks one small hole was burned through the wall. As this was below the level of the floor in the bin it did no damage. Fire smouldering along the conveyer belt passages beneath these grain bins caused an explosion on February 6th which blew the top of one of these bins into the river.

The Fire.—The fire was started about 10:15 a.m., by an explosion in the dry-house. Both the north and east walls of the dry-house were blown out by the intensity of the explosion, and as the plant was in operation and all fire doors open, the mill was filled with fire on all floors at the same time.

There was a fair easterly wind which drove the flames across the bridge into the cleaning building and elevator A; and when the mill and warehouse No. 1 were on fire, subjected the concrete warehouse to a fearful exposure. About 11 a.m. the contents of the reinforced concrete warehouse began to blaze, the fire starting on the third and fourth floors where there were large piles of box shooks. Owing to the lack of pressure, the firemen were forced to leave the building to the mercy of the flames.

Early in the fire the wired glass in the east face of the building was hanging in sheets down the wall, and the wooden frame and sash from the south wall were completely incinerated. It was in the west and middle windows of the second and third floors, that cast-iron sash weights were found partly fused.

The fire raged in the concrete warehouse without one drop of water being poured on it till 6 p.m., when 6⅔ bays north of the centre of the building fell.

In falling, the north wall of the dry-house buried the boiler room, and the east wall carried with it a 6-inch sprinkler riser, at the same time burying the valve controlling this riser. The fire in the mill opened up the sprinklers fed by two 6-inch connections, with the result that with three 6-inch streams drawing from one 8-inch main, the pressure was reduced to practically nil. Thus the private fire protection was put out of commission at the very start, and during the early stages of the fire the city system was badly crippled.

Damage to Building.—So intense was the fire that not even one charred stick of wood may be found on the plant. Fig. 5 gives a general view of what remains of the concrete warehouse. As shown on Fig. 2, most of the concrete building north of its centre line collapsed and Fig. 6 gives a view taken from the fourth floor of the south section looking towards the standing 1⅓ bays to the north. Portions of the floor slabs hanging by their reinforcing rods are plainly visible. A closer view of this wreckage is given in Fig. 7, and a view from another angle is given in Fig. 8. The brick wall in the foreground of Fig. 8 is not a part of the concrete warehouse.

From the distribution of the debris it may be concluded that in collapsing the building settled straight downward.

Temperatures Developed.—Eloquent testimony as to the temperatures developed in the reinforced concrete building is given by expansion cracks. Owing to the heating of the floors and their consequent expansion, the length of the building considerably increased, and caused peculiar diagonal cracks to appear in the brickwork. One curious effect of expansion due to heat was found in the

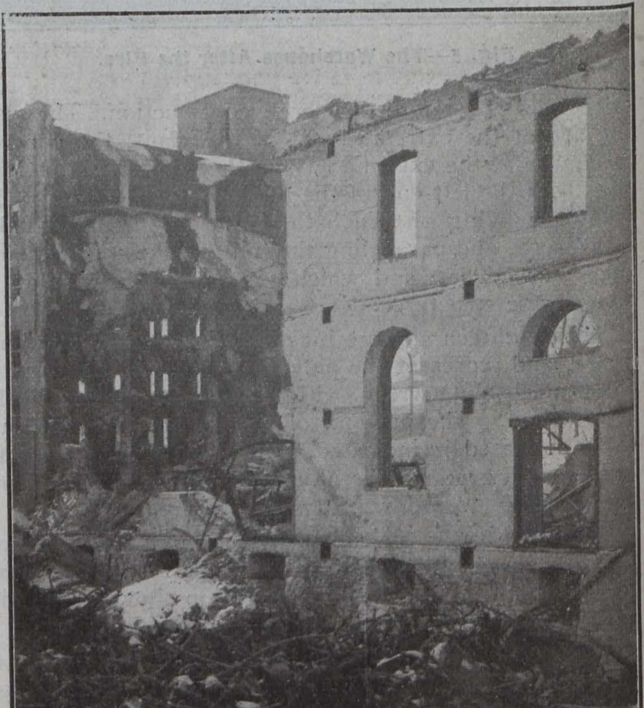

Fig. 8—Another View of the Wrecked Structure. Wall in foreground belongs to another building.

elevator pent-house. The upper end of the elevator guides came to within an inch of the ceiling formed by the pent-house floor slab. Due to expansion, these guides pushed two holes through this slab.

In the dry-house the limestone has been calcined to a depth of nearly a foot. This is evidence of long-continued heat. At many points about the plant freight cars were standing and all but the metal parts were entirely consumed, and wheels lost nearly all semblance of their original shape. On the rim of one wheel noted by the writer is a fused mass of metal where this wheel and the rail upon which it was standing were fused together. Outside the walls of the buildings a temperature sufficient to melt cast iron was developed in many places.

The temperature in the interior of the building in places must have been very intense, for melted metal parts of machines may be found here and there in the ruins. In the front windows of the second story and in the front and some of the west windows on the third story of the concrete warehouse were found melted sash weights. In some cases they were but slightly fused, in other cases two or more weights had run together, and in several places on the third floor the weights were reduced to shapeless masses of cast iron.

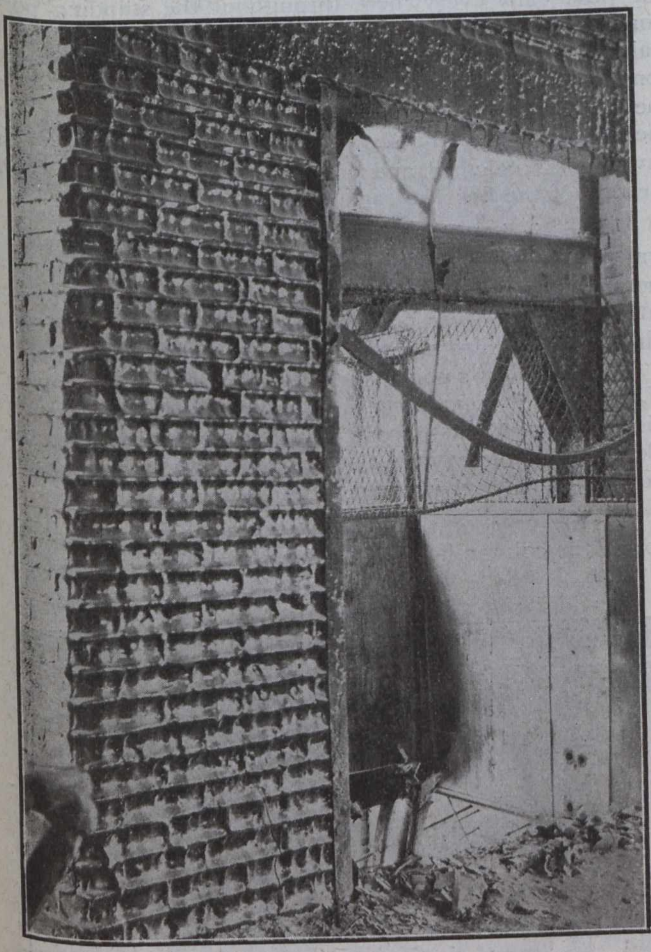

Fig. 9—Melted Brick Ran Out Upon Floor for Distance of Eighteen Inches.

On the inside of the walls of all the buildings may be found large patches of fused brickwork of which Fig. 9 gives an example. This view was taken on the third story of the reinforced concrete warehouse. The melted brick ran down the face of the wall and out upon the floor like molasses for a distance of about 18 inches, and over the doorway it trickled across the face of the concrete lintel and dripped from there to the floor. Upon breaking off some of this fused brick from the lintel, it was found that the concrete had been badly calcined beneath the running brickwork. From the fact that cast iron melts at about 2,200° F. and that brickwork reaches the stage of incipient fusion at about the same temperature, it must be concluded that at many places during the conflagration, temperatures in the neighborhood of 2,300° F. must have been reached. Fig. 10 shows a group of samples collected as evidence of the heat existing.

Cement Dehydrated.—That the concrete building became such a wreck is something that may cast grave doubts upon the fire-resisting qualities of flat-slab construction. Six and two-thirds bays out of fourteen have fallen in an almost shapeless heap of debris. The cement

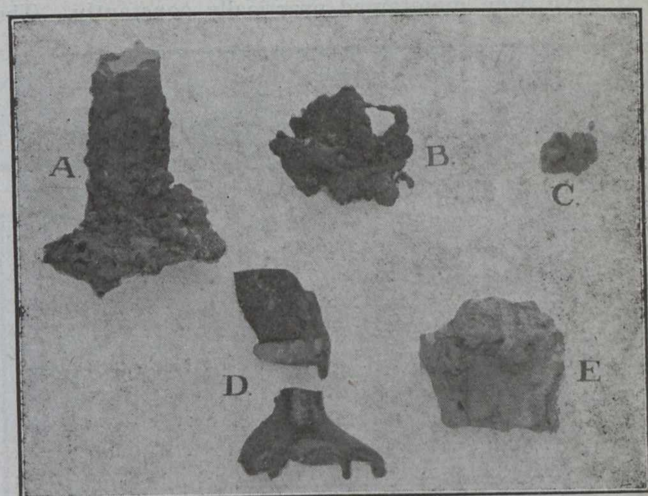

Fig. 10—Evidences of Extreme Temperature.

A is a partly fused sash weight. B is a piece of iron from a completely fused sash weight. C is a bit of glass from one of the wired glass windows which was sprinkled on the floor. D is a piece of melted brick broken from a wall. E is a piece of brick from a window sill where brick surface and wired glass were melted into one mass.

in the floors of the parts still standing is dehydrated completely through, and when a block of the floor slab, such as may be seen hanging from the reinforcing rods, is detached, it may be broken easily by dropping it on the ground or rapping it against another such block. The floor slabs practically everywhere sag somewhat, and in many places are at the point of incipient failure. Fig. 11 is a view illustrating this condition.

If we consder the effect of heat upon concrete it may shed some light on the subject. Experiments upon the

Fig. 11—Sagging Floor Slabs are at Point of Incipient Failure.

heat conductivity of concrete are rather few, but from those of Prof. Ira. H. Woolson we learn that when subjected to a temperature of 1,500° F. for two hours, a point 2 inches from the exposed surface of a block of concrete had its temperature raised between 500° F. and 700° F. We learn also that dehydration of the cement crystals begins about 500° F. and is complete at about 900° F. Thus we may reason that dehydration has reached a point of 2 inches below the surface of a piece of concrete after being subjected to a temperature of 1,500° F. for two hours.

In the reinforced concrete warehouse under consideration, we had a temperature that, according to those who saw it, "was like a blast furnace by 1 o'clock," and which at the time of the collapse, at 6 p.m., had lasted five hours. We have seen that it must have reached 2,300° F. and that owing to the great quantity of fuel, must have been maintained practically constantly. The

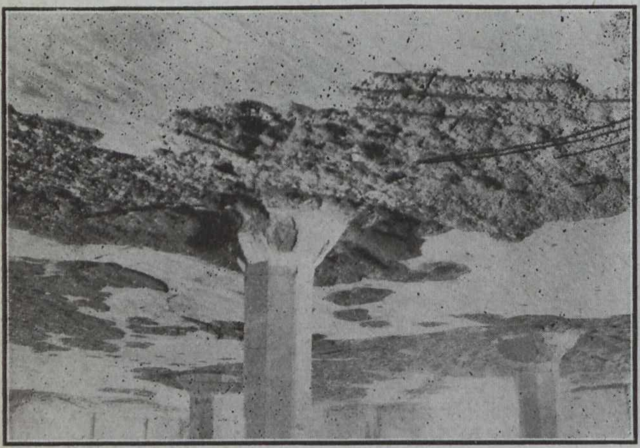

Fig. 12—Probably the Result of Excessive Compressive Stress.

fact that the floor slabs are completely dehydrated is therefore not beyond comprehension, nor does it contradict the evidence of the experiments quoted.

In addition to this, Prof. J. B. Johnson, in his "Materials of Construction," states that the working strength of steel decreases with a rise in temperature, and that this decrease takes place at the rate of approximately 4% for each 100° F. increase. If we take the evidence of the brick shown in Fig. 9, which shows that a temperature of over 2,000° F. penetrated two inches into a material of just about the same conductivity as concrete, and, from this assume that the slab rods reached this temperature, it is evident that their working strength was reduced by about 80%.

For steel with an elastic limit of 35,000 lbs. per square inch, this would mean that the available working strength was less than 7,000 lbs. per square inch. In the columns this would not be of such grave importance as in the floor slabs, but in the slabs the stresses developed were in access of this reduced allowable stress, as will be shown later. It is therefore probable that owing both to the weakening of the concrete in compression and the steel in tension, the floors failed first and carried the columns with them.

Whether any other type of construction would have stood the fire better is, of course, a matter of conjecture, but the shipping shed, which was of beam and slab construction, was wrecked when under no load.

Some Details of the Wreck.—As mentioned above, blocks of the concrete may be readily broken. At a depth of about an inch the aggregate thus exposed shows no noticeable effect, unless it be of some coarsely crystalline structure, such as granite. One such piece of granite as big as a man's fist was easily crushed by the grip of one hand. Closer to the surface the aggregate calcines. The surfaces, being directly in contact with the fire, were everywhere calcined from ¼ in. to ½ in., and on those blocks which fell into the fire in the collapsed portion calcination is practically complete.

At no point is there any evidence of fusion of the aggregate in the concrete. Particular care was exercised in verifying this fact, for in the fire at the Edison Phonograph Works at West Orange, N.J., in 1914, such fusion occurred. At first glance, material hanging from cracks in the ceiling might be taken for fused concrete, but chemical analysis makes it practically certain that this is phosphatic material from "Quaker Oats" which was piled in cases on the floor above. In the exact centre of Fig. 7 is the head of one of the basement columns, and it looks as though fusion had occurred at this point. It was largely for the purpose of determining whether or not this was fused concrete that occasioned my second visit to Peterborough, and I found that conditions had changed considerably since Fig. 7 was photographed. No fusion was evident, but the large calcined masses are rapidly air slaking. This slaking process had already started at the time of my January visit.

All floors had been given a 1-inch wearing surface and practically everywhere throughout the standing portion of the building this 1-inch surface has left the main slab. The ash from the burning box shooks protected some parts of the floor surface during the fiercest part of the heat. Although the wearing surface did not leave the floor slabs so noticeably under the box shooks, it is nevertheless calcined and can be readily separated from the rest of the floor by tapping with a hammer.

There is in this fire much to cause doubts whether gravel aggregate (other than possibly quartz gravel) reduces the fire-resisting properties of concrete. The aggregate is exposed over practically the entire ceiling of the third story and also on other stories in places, and patches of the remaining smooth surface are constantly dropping off. It would seem perhaps more correct, in the case of this building at least, to attribute this appearance to the calcination of the cement and gravel at the surface, which allowed it to fall of its own weight.

In the case of the deeply affected part of the slab around the column head in the foreground of Fig. 12, the

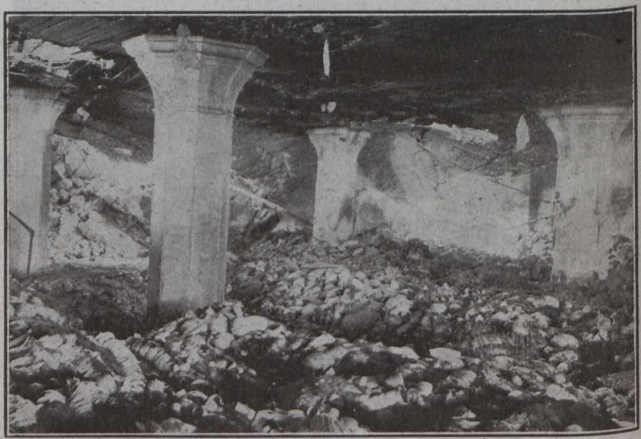

Fig. 13—View in Basement Where Premiums Were Stored.

result is more than likely due to the compressive stress that existed in this locality. Exposed corners on horizontal surfaces suffered everywhere.

The reinforcing rods, even though protected in some cases with a very thin coat of concrete, were not oxidized until exposed. This might have been inferred from the fact that a thin coat of cement mortar will prevent rust, which is somewhat analagous to the black oxide formed on metal when subjected to fire; and wherever a slab failure occurred the broken ends of the rods were drawn down as in any typical tension failure.

The shape of columns seems to have something to do with the damage they sustain. With the exception of two, square ones appear not to be badly affected. But the appearance of all the columns is very deceptive except perhaps those of Fig. 13, which are not so bad, being in a part of the basement where there was less combustible material (premiums such as china bowls, etc.).

The dehydration spoken of before has affected the columns as well as the slabs, and extends to well inside the circular hooping. A month ago this was scarcely apparent. The protective effect of the coat of grout given to the columns on the third and fourth floors was very misleading. The weather in the meantime, however, has caused the appearance of the concrete to change. A month ago a freshly fractured piece of dehydrated concrete could scarcely be distinguished from a good piece, but the weakness is now apparent, the mortar amongst the aggregate having more the appearance of dried blue clay.

It is altogether possible that the hooping on the columns is largely responsible for their not failing. On all columns a few light blows with a hammer will detach large pieces of the concrete outside the hooping, as may be seen in Fig. 14.

Fig. 14—A Few Light Blows with a Hammer will do this to an Apparently Whole Column owing to Dehydration of the Cement by the Extreme Temperature of this Fire.

Naturally, in heaps of combustible material burning on the outside, gases were formed within the pile and slight explosions thus occurred. There could not have been any explosion of magnitude. The building apparently settled straight downward. A number of columns apparently dropped directly down. As much of the brickwork appears to have fallen inward as fell out.

As to some of the details of construction, the solid metal fire doors stood the heat much better than the wood tin-clad doors when subjected to about the same heat condition. The door shown in Fig. 15 is a total wreck. The other half of this door cannot be found anywhere. The trap doors in the stairway are complete ruins. From this we may reach the conclusion that trap doors can never take the place of a proper stair enclosure.

Early in the fire the wired glass was completely gone, and may be found hanging in sheets down the outside of the walls or running down the brick inside. It must have kept the fire out of the concrete warehouse a little while, for the first fire to gain admittance did so through an open window near the north end of the building; but as to resisting severe exposures its value is not great. It is possible that iron shutters, if they had been in working order, would have afforded much better protection; for even if they were not of the automatic closing type, the employees had time enough to close them by hand, as they did the openings in the wired glass windows. The metal window sash and frames withstood the heat very well. The wooden frames were, of course, quickly consumed and the plain glass was worthless.

Fig. 15—Tin-Clad Wooden Fire Doors Were Practically Useless.

Loading of the Building.—In the sixth floor the sacked Vim feed was piled 13 sacks high, each sack weighing 70 lbs. over the whole area north of the elevator shaft. Therefore, there was a load of over 175 lbs. to the square foot. The fifth floor loading, Quaker Oots in cases, was comparatively light; and on the third and fourth floors, occupied by the package department, there were no great loads except in a few bays in which were rolls of paper. The second floor was probably the most heavily loaded, for here sacks of oat hulls weighing 98 lbs. each were piled 13 high, and sacks of rolled oats weighing 90 lbs. each were piled 11 high. This loading occupied most of the floor with the exception of a trucking space down the centre. The first floor, occupied by the shipping department, had practically the same loading as the second floor. In the basement were some cases of dishes, some bales of scrap paper, and a large quantity of sacked oat hulls. While this material added no weight to the floors, the ground oat hulls in burning must have helped to weaken the first floor. That the excessive sagging is confined entirely to the wall panels is therefore not at all surprising, nor is it any wonder that in areas of excessive compressive stress the concrete has fallen as shown in Fig. 12. The interior panels all sag somewhat, but the deflection in them is not comparable to that in the wall panels.

TRAFFIC CENSUS: ITS APPLICATION TO THE DESIGN OF ROADWAYS, SELECTION OF PAVEMENTS, AND TRAFFIC REGULATION.*

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A RECENT article in "Engineering Record," of New York, deprecated taking a state-wide census on the roads in a nearby state, because such an enumeration would not necessarily indicate the roads to be improved, as travel might, for various undetected reasons, be deflected from the most economical route.

This statement serves to draw attention to the fact that the census is but one of several things to be considered, in designing a road, including determining the kind of surfacing and the width, and that an inventory of all the factors affecting it must be taken, before a final conclusion is reached. The writer does not believe that highway engineers are to-day determining roadways, or the location where main roadways of travel should be improved, solely by scanning a traffic census; there are too many other controlling conditions, and the census is too little known and used, as yet, to be of much service. Nevertheless, it has a place in the design of country roads, and has loomed up recently with a large and important aspect in great cities, as will, I believe, be shown later.

In fixing the width of any roadway surface, the number of lines of traffic to be accommodated should be given consideration. The statement has been made that, where a vehicle has to turn off a hard surface of a road on to an earth shoulder oftener than five times in a mile, it is cheaper to construct the additional width of road surface which may be required, and is far safer.

Now, the necessary amount of clearance which a vehicle must have to pass safely, depends on the speed. The average width of vehicles in New York City has been found to be 6 ft. 9 in., large trucks occupying as much as 8 ft. or 9 ft. At slow speed, say, 10 miles an hour, with the average width, the width of a single line of auto traffic, including clearance, would be about 8 ft., and at fast speeds, 9 ft. or more. On Fifth Avenue in New York City, its busiest avenue, there are six lines of auto traffic, occupying 55 ft., the speed being between 5 and 8 miles per hour. It is obvious that, if the roadway had been made, say, 3 ft. narrower, another line of travel—or possibly two—would have to be sacrificed. The width of the Fifth Avenue roadway was originally 40 ft., accommodating four lines, with too much clearance. It was widened 15 ft., and now takes six lines, with a safe clearance. It is obvious that great congestion would have occurred, and much inconvenience to the public, had the street continued with only four lines of traffic and its excessive width.

On a suburban or country road accommodating auto traffic, the additional clearance required by an overtaking car should be considered. When moving at, say, 25 miles an hour, at least 4 ft. of free way should be given the overtaken car, to avoid accident due to unexpected deflection from its course. A width of 20 ft., for this reason, is better than 18 ft., for two lines of travel, and 30 ft. is ample for three lines.

In the Borough of Manhattan, a realization of the necessity for widening the narrow crosstown roadways of the mercantile district, and some of the north and south avenues as well, took shape in 1911, and has resulted since then in the widening of fourteen streets and avenues 35,012 ft. in length, and apparently the work has just been begun. On all of these streets, a ten-hour census of the vehicular and pedestrian traffic was taken, and resulted in bringing to light places of unexpected congestion, and afforded clues as to how the traffic can be diverted.

It was found that, where the maximum number of vehicles per foot of width per minute exceeded 0.5, there was such serious congestion, that a remedy needed to be applied. Likewise, where the maximum number of pedestrians per foot of width per minute exceeded 5.0, that they flow over the sidewalks into the roadway. Where both these conditions obtained, the street would need to be widened.

So far, this difficulty has been obviated by clearing the sidewalks of stoops, railings, court yards, areas and other projections, thus affording additional space for pedestrians, and then widening the roadway to accommodate the suitable number of lines of travel, provided such widening did not produce an unduly congested condition for the pedestrian traffic. The traffic census has made the strongest kind of supporting data for promoting legislation for the foregoing work, and shows indisputably the need, or otherwise, of street widening.

The influence of the per cent. of horse-drawn traffic on the kind of pavement, its grade, and alignment should be given weight. In cities with intensive traffic, where more than 75 per cent. is auto, sheet asphalt is, in the opinion of the writer, the pavement par excellence; if the traffic is evenly divided into rubber and iron tires, wood block stands out pre-eminently, while, for the slow-moving horse-drawn traffic, amounting to more than 50 per cent. of the whole, close jointed granite blocks are eminently satisfactory, these limitations to be applied, of course, where traffic conditions are considered as the controlling factors in forming a decision.

The difference in traction between these three kinds of pavement, as indicated by tests shown in a pamphlet on "Tractive Resistances of a Motor Truck," by A. E.

(Continued on page 172.)

*Paper read at the annual meeting of the American Road Builders' Association, Boston, Mass., February 9th, 1917.

Large contracts for lumber, aggregating 16,500,000 feet, exclusive of an open order for all the clear spruce available, has been placed by the Imperial Government with British Columbia mills.

Victoria, Vancouver and Chemainus mills will supply two cargoes of railroad ties ordered by the British Admiralty through a San Francisco house, this order approximating 7,000,000 feet.

Another order has been placed direct by the British Government for 3,500,000 feet of lumber, 2,000,000 feet of which will be clear fir, the remainder being heavy timbers, which will be shipped through to St. John, N.B., and handled from that point by British transports.

In addition, a third order has been placed by the Admiralty for 500,000 box shooks, approximating 6,000,000 feet, this order being divided between the Brunette Saw Mills and British Columbia Manufacturing Company, of New Westminster; J. Hendry Company, Vancouver; Lemon & Gounason, Victoria, and the Cameron Mill Company, also of that city.

The total output of clear spruce for airplane manufacture and shipments are being sent overseas as fast as the mills can supply this class of lumber. The new orders are welcomed by the mills, not from the profit standpoint, as the prices are about as low as it is possible to handle the business, but because the placing of these contracts with the British Columbia mills will assure steady operation for some months to come.

SHEET ASPHALT PAVEMENTS.*

By T. Linsey Crossley, A.M.Can.Soc.C.E.,
of J. T. Donald & Company, Chemists, Montreal.

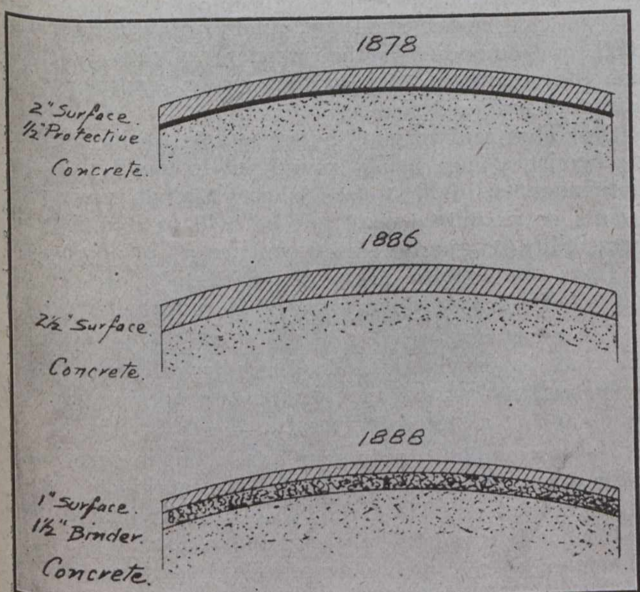
THE four essential parts of a sheet asphalt pavement are: 1, subgrade or foundation; 2, concrete base; 3, binder course; 4, surface or top.

Subgrade.—A proper study of this important element is essential. It is the portion of work most affected by local conditions of soil and topography.

Soils may be roughly divided into three main classes, though of course there are several variations of each: 1, gravelly or sandy; 2, loamy; 3, clay.

The first two classes present the least difficulty to the asphalt engineer. They drain well, and surface waters are not likely to be in contact with the concrete base, thus avoiding frost troubles. Backfilling of excavations can be thoroughly done by watering, with considerable saving of labor and time. The preparation of the grade to good crown and smooth surface is also less expensive. Where the townsite is on a slope of light alluvial soil at no great depth over rock or hardpan, some measures should be taken to prevent shifting of soil under streets running at right angles to direction of slope.

Clay represents the extreme of difficulty in preparing subgrade. Many elaborate means of subdrainage have been used. Different cases call for different treatment, but common sense is of more value than precedent in many cases. The object in view being the rapid elimination of water from the soil immediately under the concrete base.



Development of Sheet Asphalt Since 1878.

According to Richardson the cushion coat of 1878 was put on to protect the friable natural cement from destruction during the hauling of surface material, and the binder course owes its origin to an endeavor to fill the course surface of macadam roads before applying surface mixture.

Preliminary to the preparation of subgrade and of considerable importance is the proper consideration of the condition of sewers, gas, water, and wire mains. These should be closely looked into, repairs made and trenches very carefully backfilled.

In many cases, cable, water and gas mains may be located at sides of roadway so that subsequent repairs will not necessitate breaking up of pavement. It is almost impossible to patch a pavement so that the repair will not present an increasingly noticeable defect. Small towns growing rapidly should be especially careful about the consideration of such pavements, taking plenty of time to find out what future requirements of underground work may arise.

Concrete Base.—The subgrade being satisfactory, or considered so, the concrete base is laid. A 1:2:5 or 1:3:6 cement concrete is used and, except in very narrow streets, should be six inches thick. The surface should

Failure at Curb.

Bad binder and frost both acting to break up pavement Sufficient bitumen in binder probably would have prevented this.

be true to crown and free from depressions. The finish should be given by a heavy template.

It must be borne in mind that a sheet asphalt surface is not a solid but a more or less fluid body and will conform to any variation in the fixed concrete on which it rests. It is impossible to get a smooth asphalt surface over a rough concrete base. It may look right when rolled but a year under traffic will serve to show on the surface the profile of the base.

Binder Course.—This is laid on the concrete base and consists of crushed stone and asphalt, as a rule. It is essential that the concrete be thoroughly set and dry. If this is not the case there is great risk not only to the base itself, but that the moisture given off will honey-comb the binder and surface courses, causing rapid deterioration of the pavement.

There are two forms of binder course, "closed" and "open."

Closed binders consist of crushed stone and coarse sand. The stone should not be "crusher run," as this contains too much fine material, presenting an unnecessary amount of surface. This requires more bitumen and is difficult to lay smoothly.

"Closed" binders should contain little or no material passing 60-mesh sieve, about 15% to 20% passing 10-mesh and about 20% to 25% passing 4-mesh, remainder should pass 1-in. ring for 1¼-in. course, or ¾-in. ring for 1-in. course, to prevent possibility of excess of oversize. This would require for coating about 4% to 4.5% of bitumen. "Open" binder should consist of crushed stone which has been screened free of sizes under ¼ in. It will require about 3% to 3.5% of bitumen.

*Paper presented to the Canadian Society of Civil Engineers at Montreal, January 11th, 1917.

Binder course should look bright and glossy when laid. If it appears dead and dull, it has been overheated or contains fine material in excess. "Open" binder should always look bright. If the trucks bringing binder to the street are dripping noticeably, or if, on spreading the binder, there is a spot completely filled with bitumen, an excess of bitumen is being used. Such spots, if of larger area than one square foot, should be removed. One way of preventing this trouble is to dump the truck ahead of requirements to such a distance that all material must be shovelled over. If any large spots of this nature are left, the excess of bitumen is liable to be drawn into the surface course under the influence of the sun and give rise to soft spots in the pavement.

Surface or Top.—This consists of bitumen, filler and sand. The Trinidad asphalt containing about 30% of finely divided mineral matter requires no additional filler but has to be fluxed with a specially prepared heavy asphaltic oil to the required consistency before being mixed with the sand aggregate.

In addition to sand, dust is required as a filler, to utilize the malthas or liquid asphalts. The science of controlling these aggregates has been developed to such an extent in America that the present use of natural rock asphalts is very limited here, being confined to cities and towns within very short haul of the deposits of the bituminous limestone or rock asphalt. Where the rock asphalt is used the whole of the surface material is hauled, whereas with the liquid asphalts only the ten or twelve per cent. of bitumen is hauled, the material for the aggregate being generally obtained locally.

The filler is cement or limestone dust, preferably cement, and the mixture of sand and cement is graded from 200-mesh to 10-mesh. Sands do not behave in the same way with bitumens. Some will hold more bitumen than others. In connection with the filler, it is desirable, especially if heavy traffic is expected, that a large proportion of the 200-mesh material shall be dust that will remain suspended in water for fifteen seconds, otherwise the fine material is sandy and will not make a road to stand heavy wear. The finest of sands may have about thirty per cent. of voids; in fact it has been shown that the voids in sand do not vary much over quite a wide range of size. The life of an asphalt surface depends on the filling of voids and the complete covering of all particles with bitumen.

Speaking generally, a surface mixture may contain:—

(1) Bitumen, equal to 10.5% to 12.0%.

(2) Filler (200-mesh), 12 to 15 per cent. Three-quarters of this material should be fine enough to remain in suspension in water for fifteen seconds.

(3) Sand, 100-mesh, 13%; 80-mesh, 13%; 50-mesh, 15%; 40-mesh, 15; 30% mesh, 10%; 20-mesh, 10%.

Local conditions, however, may occasion considerable variations. Sand should be sharp and clean. The objection to a dirty sand does not lie in the fact that fine silt is present, but because the particles of such a sand are coated with this silt and therefore are not brought into complete contact with the hot asphalt when the mixture is made.

If local conditions make it necessary to use such sand, it might be cleaned by passing through a revolving screen or by dropping down a vertical chute on to a baffle plate.

Preparation of Specifications.—In connection with a contract for paving with asphalt in any of the various methods, the inspecting engineer and chemist are, or should be, called into co-operation at the earliest stages of the proposed work. They should know local conditions of soil, drainage, and traffic. With these in view, specifications should be drawn up. It has been too frequently the practice to copy specifications of other cities, especially where these are known or reputed to have good pavements.

Especially to be avoided is the inclusion in a specification of some feature introduced with success in one or more cases to counteract some special local condition, or on account of the local availability of some special material. Richardson cites a case wherein an engineer specified cinders for subgrade drainage and insisted on their use. A large quantity was used, subject to a 200-mile haul, when good gravel was available within easy carting distance.

In drawing up specifications for the sand aggregate of a sheet asphalt pavement, the question of sand supply should be studied and the best grading from this supply should be specified. This will forestall the necessity of permitting variants from specifications.

The following is suggested as a preamble to specifications for a sheet asphalt paving:—

"The object of these specifications is:—

"(1) To provide a means of ensuring that a first-class sheet asphalt pavement be laid in the town of Blank,

"(2) To regulate the conditions under which it shall be laid, and

"(3) To state what limits of chemical and physical properties in the materials used, shall be deemed sufficient and expedient to that end.

"Parties tendering to supply and lay pavements under these specifications will be compelled to comply with the conditions set forth, in every detail, without recourse, excepting only as follows:—

"(*a*) That notice shall be made in writing, duly signed, and embodied in their tender, of any variants which the conditions of manufacture or experience of contractors makes desirable.

"(*b*) That said variants be acceptable to the engineer and chemist as not being prejudicial to the laying and maintenance of a first-class sheet asphalt pavement. Variants so permitted shall not be held to diminish the responsibility or guarantees of contractors in any way."

Tests of Asphaltic Materials.—Several pieces of apparatus have been devised for asphalt testing.

The penetrometer records the depth, in tenths of a millimetre, to which a standard needle will sink in the sample, under a stated weight, for a given number of seconds and at a stated temperature.

This seems like a very simple test, but in carrying it out for accurate comparisons, the precautionary sense must be ever alert. The bitumen is carefully heated until liquid, when it is poured into a small tin about 1¾ inches in diameter by 1¼ inches deep. This is kept in the laboratory air for about an hour and is then kept in water of the stated temperature, in most cases 77° F., for another hour. It is then transferred to a crystallizing dish deep enough and wide enough to admit of the tin containing the bitumen being immersed in water of the same temperature as the container in which it has been held. The penetration is then taken by releasing the weighted needle at the surface of the bitumen.

In tests such as penetration and ductility, the low conductivity of asphalts and asphaltic cements must be taken into account. Penetrations should not be made unless the test portion has been standing in water of the required temperature for at least an hour, during which time the temperature must not vary over 1°. One 16-c.p. carbon filament lamp will maintain a temperature of 77° F. in a moderate sized pan with very little attention.

Penetrations at the freezing point require care. The surface of the test sample must be kept at exactly 32° while the test is proceeding, because the needle is released and acts at the surface. In most cases the penetration is only 1½ to 2½ millimeters.

The material to be tested is melted and poured into a tin as described above. This tin is held at the freezing point for one hour, after it has cooled to laboratory temperature, before making the test.

Four penetration tests are usually made on a sample, at 32° F., 77° F., 115° F. and at 77° F. after the material has been heated for five hours at 325° F.

Good refined asphalt and asphaltic cement should not show a hardening of more than ten or fifteen points, and will not lose more than a fraction of 1%. Trinidad and Bermudez asphalts lose a little more than those prepared from Mexican asphalts. A recent sample of Bermudez refined, tested by the writer, lost about 1.5%.

Other tests made are solubility in carbon bisulphide and carbon tetrachloride, and ductility. The last is made by measuring the distance which a briquette, having a cross-section area of one square centimeter at its centre, will stretch horizontally before it breaks. Good "AC's" should run over 100 centimeters when pulled apart at 77° F. at a rate of 10 centimeters per minute. The thread produced as the pulling proceeds varies in thickness a great deal. Some at 100 to 110 cms. show a strong line of about the size of No. 60 thread,—while others at same length show such a fine filament that a glass has to be used when looking for breaks.

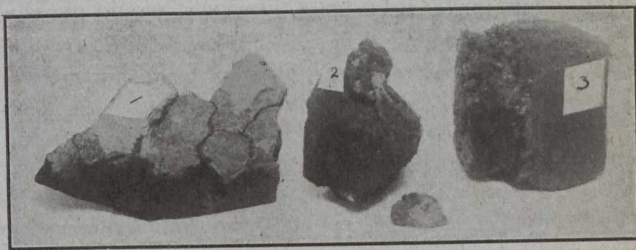
Tests not always made, but having more or less value for comparing samples as to uniformity and for determining whether the heating has been carefully done, are: Fixed carbon, ash, flash point, proportion of paraffin scale, and solubility in naphtha (76° or 86°; gravity should be stated).

The fixed carbon test has come into undue prominence because too narrow limits have been set for it. The test is subject to fairly wide personal factor, depending on the difficulty of securing exactly similar conditions at different laboratories. It consists, briefly, in strongly beating one gram of the bitumen away from the air for a stated length of time, producing a coke, as in the proximate analysis of coal. The weight of the system is then taken and it is burnt in the air to ash, the difference being the fixed carbon. The thickness, depth and volume of the crucible, the height and intensity of the flame and the time of heating, all affect the results, so that this test must not be considered as an exact one. It yields valuable information sometimes as to the history or origin of the bitumen in question. California asphalts yield a lower fixed carbon for the same class of material than Mexican, for instance.

Break-Up of Binder.

Due to insufficient bitumen. Under traffic the crushed binder tends to pile up, producing waves which eventually break at the crest, admitting water, which very soon puts an end to the pavement, especially when helped by frost and traffic.

The ash test also serves to show something of the past of asphalt. For instance, if a refined asphalt was said to be Trinidad, and showed only 10% ash, we would know it was not straight goods.



Two Bad Samples and One Good One.

Sample No. 1 shows underside of asphalt laid in repair work over cement not set and still wet. The moisture gradually works through to the surface, producing a reticulated appearance, eventually leading to break up of pavement.

Sample No. 2 shows a bad binder condition. There was not enough bitumen in this binder and what there was did not adhere to the stone used. The stone lying loose fell out of the matrix just under the label.

Sample No. 3 shows well made binder and surface; all parts adhering properly.

Low flash point asphalts would be dangerous to workers owing to the necessity of high temperatures in mixing machinery and melting tanks.

Inspection.—When tenders are submitted, it is the custom to submit samples of asphalt, asphaltic cement and flux (only the A.C. sample being submitted, of course, if the A.C. is shipped already fluxed by straight refinery distillation). It is always advisable, besides determining the suitability of a sample and its compliance with specifications, to learn something of its history. Cases have been known where samples of one make were submitted as being of different brands. The engineer or chemical engineer charged with the inspection should make a personal visit to the plants from which the asphalt is to be shipped and note its manner of shipment and the means taken there to control the product.

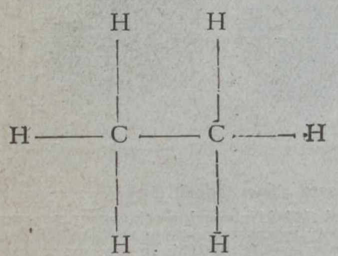
When the paving is to be done by a contract separate from that for the supply of the materials, it will be necessary, of course, to check quantities received as well as quality. If the contract is to supply a finished pavement, the quality only of the bitumen is to be noted and, of course, the proportions of the aggregate.

The mixing plant should be closely examined and tested as to the capacity and sensitiveness of its weighing and mixing machinery and method of heating. The means for maintaining a sufficiently high temperature without overheating the material is an important point. With a substance that has such a low conductivity as asphalt, direct heat must be used with great care, especially in starting up with cold material. Some means of circulation should be provided until the material is liquid enough to circulate by convection and even then should be stirred to prevent burning at the bottom. A range of temperature from 350° F. to 425° F. should not be exceeded, either above or below, even in cold weather.

The sand should be heated to the same temperature as the bitumen. While no damage will accrue to the sand by heating to higher temperatures, there is a risk of the asphalt being damaged or burnt by overheated sand. The same consideration affects the heating of the crushed stone used in the binder course mixture.

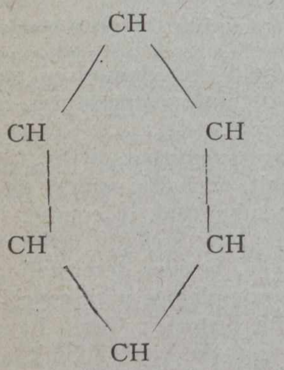
At a plant of any size an inspector should be employed continuously. It would be his duty to see that weighing apparatus is kept efficient, that asphalt is not overheated or allowed to get so cooled as to cause mixture to become lumpy at laying point, that sand or crushed stone is clean, of proper grading and heated to the right temperature.

He should have a small, clean room for his own use entirely, a scale weighing up to two or three kilos and sensitive to 1 gram, a set of sieves from 200-mesh to 1-inch ring. It would be well also to have a penetrometer and dishes for the penetration tests, with a supply of water. The penetration tests, however, would usually be done by the city chemist at the main laboratory. In connection with sand test at 200-mesh, or for the testing of



Open chain hydrocarbons. "Paraffins"

Propane.



Closed chain hydrocarbons. Cyclic or Aromatic.

Benzene.

Hydrocarbon Formations.

This diagram illustrates the difference between the petroleum compounds and the asphaltic oils. The latter consist largely of what are termed closed chain or cyclic compounds, whose space arrangement is indicated on a plane surface by one or more hexagonal groups. The petroleum compounds are paraffins whose space arrangement is indicated by a chain-like formula.

dust or cement as filler, there should be provided a graduated cylinder about ¾-inch diameter, holding a little over 50 cubic centimeters graduated to 0.5 cubic centimeters, to test the proportion of suspendable matter, which is the true filler. Seventy-five per cent. of the 200-mesh material should be of such a degree of fineness that on shaking it up with water, it will remain in suspension at least 15 seconds.

The plant inspector should keep records of the loads of surface mixture and binder course, their destinations and heat on leaving. A sample of surface mixture should be taken from the wagon or truck before it leaves the yard and a pat test made to check any tendency to the use of too much or too little bitumen.

Failure of Asphalt Pavements.—Generally speaking, sheet asphalt pavements do not wear out. They "fail" owing to some constructional defect. Failures have occurred from all four parts of the pavement, *viz.*, subgrade, concrete, binder and surface.

Subgrade failures are due to careless backfilling, too great haste in laying pavement where much backfilling is done, or insufficient drainage. Adequate examination of the soil and preparation of subgrade is imperative.

Concrete failures are due to lean mixtures, laying of binder before concrete is thoroughly set and dry, use of dirty sand, or use of old cement.

Binder failures are due to insufficient bitumen, burned bitumen, laying on wet concrete, dirty concrete, binder too cold, excessive oversize in aggregate, lamination in crushed stone, over-rolling of binder when cool, or traffic on binder before top is laid.

Surface failures are due to too little filler with heavy traffic, too much filler with light traffic, too much or too soft bitumen under heavy traffic, too hard bitumen under light traffic, laying top on wet binder, insufficient consideration of climate extremes, or frost working in at car tracks or curbs.

In the writer's observations, failure is due more frequently to binder troubles than to other causes. Attention is focused on the laying and appearance of "top," to the neglect of the binder. With a smooth concrete base and a medium close binder well laid, it should be quite safe to cut down the "top" thickness to three-quarters of an inch.

TRAFFIC CENSUS.

(Continued from page 168.)

Kennelly and O. R. Schurig, may be represented by the following factors, which are averages of tractive resistances at a speed of 19 miles per hour:—

Pavement.	Tractive resistances in. lbs. per ton.
Asphalt	19
Wood and brick	23
Granite	26
Macadam	22.5
Tar macadam	24.5
Gravel and cinder	26.5

The tractive resistances should, in the opinion of the writer, be given much greater weight in the selection of pavements in cities, than is usually accorded them, for the following reason: It will hardly be questioned that auto trucks, in the cities at least, will soon be in almost universal use, and when this is a fact, the consumption of fuel will undoubtedly be carefully examined into, and smooth, light traction surfaces demanded for economy of operation. To-day, with the numerous pleasure autos in use, scant attention is paid to ease of traction, grade or consumption of gasoline, and a scenic highway is at times preferred to the shorter utilitarian route, for which there is going to be an urgent demand by the auto trucks, especially in rural districts.

A few figures as to the growth of the auto truck in New York State are presented. A report of the Secretary of State states that it is estimated that auto trucks travelled over state and country highways in 1915, for 40 weeks in the year, 14,700,000 miles, and that these trucks operated 60,200,000 ton-miles. The number of auto trucks in New York State in the last three years is as follows:—

1914 17,141   1915 20,880   1916 34,653

There were in New York City in 1916 about 21,000 auto trucks, double the number of 1914. In addition, there are more than 100 routes in the State over which heavy motor buses are operating, nearly all of which are less than three years old.

The surfaces which should be placed on trunk highways and rural roads for different kinds and amount of traffic in the State of Massachusetts, have been outlined by Col. Sohier, the chairman of the Massachusetts Highway Commission, in a paper before the American Road Builders' Association, in 1913, on "The Traffic Census as a Preliminary to Road Improvement." Since that time the auto truck has increased greatly in number, having more than doubled in the State of New York, as shown.

Tables such as the foregoing will soon need careful revision, because of the weights, and the speeds at which these trucks move. The preparedness movement has served to draw attention to the fact that it is desirable to consult the War Department as to the loads to which roads and bridges are likely to be subjected for military purposes.

The increase in the destructive effect of this traffic points to the need of much harder and more durable surfaces than have been afforded by the penetration method of construction—surfaces constructed with one course run of crusher stone with bitumen; sand asphalt roads; broken stone, sand and bitumen roads; carpeted macadam; and other kinds of light traffic bituminous construction.

Recognition of the destructive effect of auto truck travel has led to a readjustment of the registration fees to a higher scale, recently in New York State. Experience with the situation is necessary, in order to determine the exact number of commercial vehicles which may traverse economically certain types of road.

Use of the Traffic Census in the Regulation of Traffic.—The traffic census finds its application to the regulation of traffic, in large cities where congestion is imminent or actual. The Borough of Manhattan has found it necessary to establish 29 streets as one-way traffic streets. These are located largely in the mercantile and theatre districts. Three of them are theatre streets with a one way rule applying one-half hour before and after the termination of performances.

A determination of the amount of traffic in all the streets of any section of a city should indicate where a diversion of the flow is desirable. So far as the writer has been able to ascertain, but one study of the flow of traffic has been made, that being in the city of Bridgeport, Conn., by Alfred S. Miller, as published in "Engineering News" of New York, of January 21st, 1916. The writer believes that such studies are highly important, where there is intensive traffic on a gridiron system of streets, to the end that alternate traffic routes may be laid out, by widening, paving, re-grading or otherwise improving, so that congestion may be avoided, and the orderly transaction of business facilitated.

A number of the large express companies and other corporations now route their vehicles, and have a regular patrol which keeps them constantly informed of the location. A study of the flow of traffic in a large, busy city may offer some difficulties, but would be helped out by instances such as the foregoing.

In the Borough of Manhattan, the Fifth Avenue Association has influenced traffic on that avenue, by encouraging merchants and others to exclude commercial traffic from this distinctly retail mercantile and residential thoroughfare, so that there is now less than 2 per cent. of horse-drawn vehicles of all kinds. This association makes its own traffic censuses, and studies traffic conditions quite independently of the city, and is in a position to make valuable recommendations as to the policy to be pursued.

It was suggested to the police department that more time be given to the north and south traffic than to the east and west, with the result that about 45 minutes of the hour are devoted to the longitudinal travel, while the cross-town traffic takes up the remaining 15 minutes. It has been proposed to divert the through traffic of Fifth Avenue to a parallel avenue, thus affording some relief to this much-congested thoroughfare.

Regulation of Pedestrian Traffic.—It is daily becoming more apparent that, if the vehicular traffic is to proceed with reasonable speed, say, 8 miles an hour on our busiest streets, it will be necessary to regulate the pedestrian traffic as well. It was found that the average time taken by a woman crossing Fifth Avenue—which has a width of 55 ft.—was 11½ seconds. In the busy hours, six vehicles would pass in that time, rendering the crossing difficult and dangerous. There is nothing to prevent a pedestrian from crossing the street at any time he may elect to do so, and he certainly needs to be told when, if the number of accidents which happen is a criterion.

The subject matter of traffic regulation can only be touched on at this time. State-wide co-operation to the end that uniform regulations may be drafted and legislated into laws, is much needed. Attention is directed to the proposed regulations of the State Bureau of Municipal Information of the Conference of Mayors of New York State, embodying the ideas of those most interested in that State. It does not, however, cover the matter of the regulation of the size, weight or construction of the vehicle itself, which is of great interest to the highway engineer.

As to What the Census Should Include.—The traffic census should include observations as to the direction of the flow of traffic, such as left-hand turns; number of vehicles emerging from, or entering side streets; routes of mail trucks and other vehicles; wandering cabs, etc., as well as a knowledge of the various classes of vehicles, if the congestion features of traffic are to be studied. The points at which the count should be taken are worthy of study, and this study is best made by plotting bands of different colors and widths along the roads or streets where the census has been taken. Work of this kind has an intimate relation to building district restriction plans, and to the city plan generally.

Uniformity in methods of taking and recording censuses, and in the assignment of weights, is much needed, for comparisons in different sections. Some office work can be saved by the use of standardized forms, and the writer would suggest that this matter be given attention by the Committee of Standards of the American Road Builders' Association, and that the co-operation of other engineering societies be sought, in making such forms.

In conclusion, the writer would direct attention to the fact that the traffic census has a wide application to city work, in the selection of pavements, street widening, the removal of encroachments, traffic regulation, fixing values of property, opening of new or extension of old streets, operation of street railroads and buses under franchises, determination of the amount of wear of various kinds of pavement under known weights of travel, regulation of the dimensions, weights, etc., of vehicles, and the determination of a paving policy.

On February 2nd, 1917, the technical staff of Wallace & Tiernan Co., Inc., of New York City, celebrated by a dinner the 500th installation of that company's chlorine control apparatus. Many prominent waterworks men and sanitarians were guests of the evening and very interesting remarks were made dealing with the early days of chlorination and the first installation of W. & T. equipment. A souvenir menu illustrated the growth of the organization. A picture therein showed Mr. Wallace and Mr. Tiernan with the first chlorinator, and another showed a portion of the present staff with the 500th machine, mention being made of district offices in Chicago, Dallas, San Francisco, and London.

A NEW TYPE OF TRICKLING FILTER.*

By Lieut.-Col. G. G. Nasmith, C.M.G., Ph.D.,
Director of Laboratories, Dept. of Public Health, Toronto.

THE object of every method of sewage-disposal is to resolve the complicated putrescible organic materials present into simpler, largely inorganic, compounds which are no longer decomposable and incapable of causing offence; in other words, it is to create a harmless and non-putrescible effluent. Such an effluent is commonly said to be "purified."

Methods such as that of the septic tank fail, because, working in the absence of oxygen, they only partially split organic material, and these products of hydrolytic action have still to undergo further destructive processes in the presence of oxygen before they become stable.

Sewage-disposal in the ordinary sense of the term resolves itself in chemical terms to the formula: Organic Matter + Oxygen = Inorganic Matter + Humus (a stable organic material).

The aim of every method of sewage-disposal has been to take advantage of the oxydizing properties of living micro-organisms. Methods which have failed are those which have not provided the necessary conditions; that is, a sufficiently large mass of aerobic micro-organisms, properly harnessed to work in the presence of an abundant supply of air.

Without going into detail it has been established beyond question that the only methods of sewage treatment which fulfil the above conditions are the Trickling Filter and the more recent Activated Sludge method.

The Trickling Filter requires specially prepared bacteria beds, several feet in depth, made of stone, slag, coke, or other resistant material, as a nidus for the bacterial growth. Sewage, when sprinkled or sprayed over the surfaces of such beds, slowly trickles over the pieces of stone until it finally reaches the bottom. In the course of a few weeks the pieces of stone become coated with a pellicle of slime, which has been shown to consist principally of bacteria and protozoa. It is this living slime which, in the presence of the oxygen of the air, oxidizes organic matter.

From the sewage slowly trickling over the surface of this bacterial slime the organic matter is abstracted and decomposed into simpler products. These simpler products are chiefly nitrites, nitrates, carbon dioxide, sulphates and a brownish-black non-putrescible material, easily sedimented, called humus.

If air is excluded from such beds, the oxidizing action soon ceases, or, if antiseptics are added in sufficient quantity to destroy the bacterial slime, the oxidizing action also ceases.

In the activated sludge method of sewage disposal, a similar bacterial mass is gradually formed by blowing finely divided air through tanks filled with sewage. The sludge which forms by this treatment is allowed to settle, the supernatant fluid allowed to run off, and the tank again filled with sewage, after which the process is repeated. By degrees the sludge which accumulates, acquires the same properties as the slime covering the filter-beds. When fully matured, this activated sludge will oxidize the organic matter in fresh sewage in from two to four hours; when agitated continuously with it in presence of finely divided air, a perfectly clear and stable effluent is obtained.

*Excerpt from the Journal of the Royal Sanitary Institute.

The two methods briefly described above are practically identical in principle. In the trickling filter the sewage trickles over the bacterial mass in an atmosphere of air. In the activated sludge method the bacterial mass and sewage are kept in intimate contact by agitation with streams of fine air-bubbles. The end results are exactly the same. Furthermore, as in the trickling filter, the vast majority of the bacterial present in the sewage, including lactose fermenters, and also, presumably, the pathogenic varieties, are destroyed. A single example will suffice to demonstrate several of these statements.

Department of Health Experimental Sewage Disposal Plant, Toronto.

Average Analyses, June 20th, 21st, and 22nd, 1916.

	Free NH3.	Alb. NH3.	Nitrites and Nitrates.	Bacteria per cc. Agar 37°C.	Red Colonies MacConkey 37°C.
Raw sewage......	16.0	7.58	2.66	1,453,333	563,333
Activated sludge-tank, 4 hours blowing 2 cubic feet of air per gallon of sewage	8.9	1.9	12.3	5,690	700
Lath-filter, treating 4.5 gallons of sewage per acre per day...	10.0	1.7	10.4	9,400	1,266

In 1912, in an endeavor to devise a method for the disposal of the city of Toronto's sewage, and reduce the estimated cost of the filter-beds, I began experiments to try to increase the efficiency of the trickling bed, always keeping the principles involved in mind. It was argued that if the amount of surface or bacterial slime could be increased in a given volume, then a greater quantity of sewage could be passed over it and oxydized in a given time.

Experiments were therefore designed with the object of increasing the surface of the filter per cubic yard, and of allowing freer circulation of air than the ordinary types of filter-beds permitted. Wood was selected as the material lending itself best to the problem, and the first filter, six feet square, was made of laths. The laths of the lowest layer were laid parallel to one another, the spaces between the laths being a little less than the width of the laths themselves. A second layer was laid on top of this and at right angles to it, with the same interspace. A third row was laid parallel to the bottom row, but in such a manner that the laths covered the spaces left between the laths of the lower series. In this way a filter four feet in depth was constructed, in which the sewage, in order to reach the bottom, had to flow over a very large surface of filter. Air could enter from all sides and the top through the regular channels provided; in fact, one can see right through this filter, so uniformly regular are the spaces.

Sedimented city sewage was allowed to trickle over the surface of this lath-filter; in less than a month the filter was mature, and the results obtained thereafter exceeded all expectations. Where the standard type of stone filter, operated side by side with it as a control, treated two million gallons of sewage per acre per day, the lath-filter treated six million gallons and yielded a non-putrescible effluent. This lath-filter has now been in continuous use for three and a half years, and has never failed to give satisfactory results.

From these results we argued that poles might give an even greater surface per unit of volume, because the poles would only come into contact along very narrow surfaces when built into a filter like the laths. Two such filters were built, each six feet square and six feet in depth; after maturing they yielded practically the same results as the lath-filter. They were, however, very difficult to construct; it was difficult also to obtain an even distribution of the sewage flow, and short circuiting of the flow was also liable to occur. This form was abandoned as not being of practical value. One pole-filter, however, was installed in 1914 at the City of Toronto Industrial Farm to treat the sewage from several hundreds of people. No provision had been made for the fact that sewage in small communities frequently comes in gushes, and consequently, as the bed was overdosed at some periods and had no work to do at others, the results were not satisfactory. These defects have recently been remedied.

A filter built of slabs of wood was discarded, as it was only capable of treating sewage at the rate of three and a half million gallons per acre per day.

Finally, having proved our theory to be correct, and having made some preliminary experiments, it was decided that brushwood, pressed into bundles, would make the ideal filter for filter beds, because it would provide the combination of a very large surface area and presence of air which is so essential.

When the town of North Toronto was annexed to the City of Toronto a few years ago it had a system of sewage disposal, part of which consisted of three trickling stone filters, each thirty feet in diameter. In the early spring of 1914 we had the stone removed from one of these filters. Bundles of brushwood, cut from the woods nearby, were made on the spot by means of a rough box-press, wired together, and placed in the filter until a depth of four feet had been obtained. A space of one foot was left between the brush-bundles and the wall, and a small space in the centre so as to allow air to enter freely from the sides. The old revolving distributing sprinkler was then put into operation, the brush quickly became matured, and in two months it was treating sewage at the rate of six million gallons per acre per day. A very high degree of nitrification has been obtained; the effluent has been uniformly stable; and the installation has proved to be a decided success. This brush-filter has now been in operation for two years, and has worked just as well in winter as in summer. Of course, it is always necessary to cover filters of every description in winter in Canada to prevent freezing. A brush-filter that was operated in the open to prove whether this would occur in the Toronto climate rapidly froze solid.

After three and a half years the lath-filter shows no signs of incipient decay, confirming the common experience that wood which is kept constantly wet does not decay. In both the lath and the brush-filter the wood is covered with slime, so that the wood is always soaked.

The advantages of the brush-filter may be summarized as follows: (1) Brush is cheap, and may be obtained almost anywhere; (2) skilled labor is not required in construction; (3) it does not sludge; the slime will frequently become quite thin after heavy rains when the sewage is diluted, though the efficiency of the filter is unimpaired; (4) the brush may at any time be removed and burned; (5) it is durable: a filter has now been in operation for over two years without showing any signs of decay; (6) the distribution of the sewage over the surface of the filter does not need to be very uniform; the general tendency is to redistribute itself in the filter meshwork; (7) it gives the maximum amount of surface, with a freer circulation of air in a unit volume of space; (8) it has proved to be a success when treating the sedimented sewage of a city on a large scale, and has treated three times as much sewage to the acre as the standard stone filter will treat.

Unfortunately, on account of the war, I have not been able to give in detail the results which have been and are still being obtained since the filters were put into operation.* This brief summary is being given in order that others may avail themselves of our experience. Patents were applied for in the year 1914, in order to protect the City of Toronto until such times as our experiments should be completed. No rights or royalties are claimed, however, in connection with the process. In fact, it is hoped that the cheapness of the system will enable communities to install systems of sewage disposal in districts where the high cost of the accepted types of installation have been prohibitive in price. In the prairie provinces of Canada, for example, where stone would in many cases have to be hauled by train for hundreds of miles and costs a great deal, the brush-filter should solve the problem in regard to expense of installation.

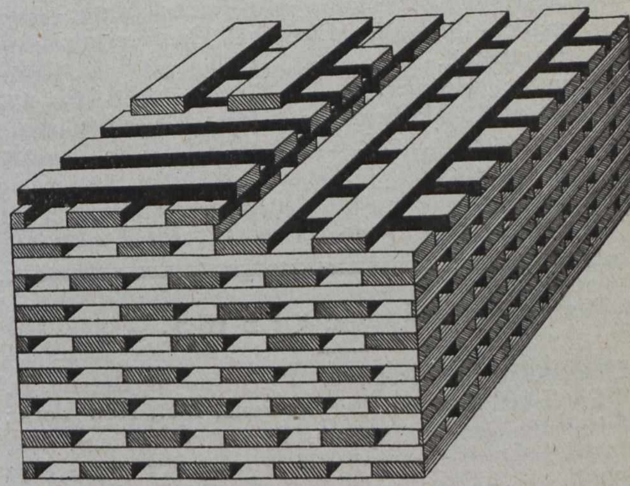


Diagram Showing Construction of Lath Filter.

In conclusion, I wish to express my great appreciation of the work of my assistants, Mr. J. Scott, chemical engineer, who has carried out the construction of, and has been responsible for the operation of all the experimental filters, as well as the chemical analyses in connection therewith, and Dr. F. Adams, D.P.H., who has supervised this work in my absence. I am also greatly indebted to Mr. R. C. Harris, commissioner of works, and to Mr. Worthington, engineer-in-charge of the sewage-system, through the unfailing co-operation and interest of both of whom it has been possible to carry out the experiments on a large and practical scale.

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*NOTE.—See article, "Brushwood as a Medium for Sewage Filters," p. 117, *The Canadian Engineer*, issue of February 8th, 1917.

The annual report of the Saskatchewan Department of Railways for 1916 recently published contains several interesting statements indicating the growth of railway mileage in the province since its inception, also branch line equipment. The instalments indicate that for the period prior to the commencement of war very great expansion in railway construction took place. The total railway mileage in the province to-day is 6,101.46, divided as follows:—C.P.R., 2,762.75; C.N.R., 2,206.78; G.T.P.R., 1,131.93.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

The Elements of Refrigeration. By Arthur M. Greene, Jr. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1916. 472 pages, 192 illustrations, 6 x 9 ins., cloth. Price, $4.00 net. (Reviewed by Harry H. Angus, B.A.Sc., MacMullen, Riley and Angus, consulting engineers, Toronto.)

This work covers a field about which comparatively few books have been written in a comprehensive manner. This book is essentially for students and the first part deals very fully with the thermodynamic side of the question and explains all steps necessary to derive the different formulæ used in the practice of refrigeration. The latter part of the book is devoted to practical problems and construction. The general divisions are arranged in good order but the matter in some of the chapters is poorly divided, which is liable to lead to confusion in reading the book.

Starting with a history of refrigeration from ancient times to modern, the work proceeds with a general description of the various types of refrigerating machines in use at present, giving illustrations and a short description of each. The third chapter deals with the thermodynamics of refrigeration and is a very complete treatment of this subject, illustrated by numerous examples.

Following the theoretical treatment, comes a description of the component parts of refrigeration apparatus, giving various types of cylinders, valves, pipes, fittings, etc. Description of apparatus made by prominent manufacturers is described and illustrated and the advantages of the different methods of construction are explained. Another chapter is devoted to heat insulation and gives formulæ by which the loss of heat may be calculated for any type of construction. Methods of calculating heat given out by machines, lights and persons are given.

The remaining five chapters in the book are devoted to problems arising in the design, construction and operation of ice plants, cold storage plants and the applications of refrigeration to the manufacture of different products. Costs of installation are fully dealt with, together with operation tests. At the present time, of course, due to rapidly fluctuating prices, the part dealing with cost of installation is of doubtful value.

The final chapter is devoted to problems illustrating the application of the text, and the problems are typical, so that this part of the work forms a reference for any problems which may arise.

As a whole, however, the work is quite complete and well worth reading by anyone interested in refrigeration.

Underground Transmission and Distribution for Electric Light and Power. By E. B. Meyer. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1916. 312 pages, 156 figures, 6 x 9 ins., cloth. Price, $3.00 net. (Reviewed by D. J. Beatty, Northern Electric Co., Limited, Montreal.)

The steady increase in the demand for power for lighting and industrial work in large cities has made it necessary to place all conducting wires in congested areas, underground. Notwithstanding the gradual evolution in the methods of underground transmission and the big investment of many large operating companies in underground work, very little literature will be found on this subject.

This new book by E. B. Meyer, entitled "Underground Transmission Distribution for Electric Light and Power," will form a valuable addition to existing literature on this subject, and is recommended to engineers and others interested in this class of work.

The subject is treated from a practical point of view and Mr. Meyer's experience as chairman of the National Electric Light Committee on Underground Construction and Electrolysis, 1915-1916, has placed him in a position to obtain valuable data from operating companies in America. The subject is treated in detail, from the construction of underground conduit systems to the final testing, operation and maintenance of underground cable systems. General information is given on the design, methods of construction, comparative costs, protection and operation of different types of systems in use to-day.

An historical chapter gives interesting information on the gradual development of underground distribution work. Working specifications covering the construction of underground conduit systems and the manufacture and installation of underground cables are also of special interest.

One feature of the book which will appeal to a great number of readers is the fact that it is entirely free from cumbersome theory and, therefore, makes interesting reading.

Winter Track Work. By E. R. Lewis, assistant to general manager of the D. S. S. & A. Railway. Published by Railway Educational Press, Inc., 14 E. Jackson Boulevard, Chicago, Ill. 175 pages, illustrated, 5¼ x 8 ins., cloth. Price, $1.60.

Mr. Lewis has given us a notable addition to track literature in his new book, "Winter Track Work." He has had a great deal of experience in handling track work and in keeping traffic open in countries where snow and cold conditions are severe. Besides this, he brings to his work the knack of writing in an interesting manner on what would ordinarily be a prosaic subject.

There is much of value in this book for the trackman; but not only for the trackman but for the operating man, the traffic man and everyone who is concerned with keeping tracks clear and traffic open in the winter.

The book has ten chapters, embracing the following subjects: (1) Climate and Track, with discussion of the differences in hot, mild, cold, wet climates, etc., etc. (2) Frost; with its effect on track and what must be done to counteract it. (3) Snow; complete discussion of the snow-handling campaign. (4) Shims and Shimming; Good Practice and Bad Practice. (5) Winter Track Force; Tools and Supplies; with especial discussion on the necessity for ample provision. (6) Snow Fences and Snow Sheds. (7) Snow Handling Equipment; with illustrations of many standard and some special appliances. (8) Spring Floods. (9) Storing Ice. (10) Organization.

Books such as this by Mr. Lewis cannot fail to help materially in raising the standard of track work on American railways.

A Manual of Field Astronomy. By Andrew H. Holt, Instructor in Civil Engineering, College of Applied Science of the State University of Iowa. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1917. 125 pages, 8 tables, 25 figures, flexible leather, 4¼ x 6¾ ins. Price, $1.25 net. (Reviewed by Prof. Louis B. Stewart, University of Toronto.)

No apology is necessary for producing a work on field astronomy which is designed to meet the requirements of the engineer or surveyor in his ordinary practice, and which therefore omits methods and refinements which are of interest only to the geodetic astronomer, who will find several standard works containing all the information he requires. Almost the exclusive use which the engineer makes of the subject is in determining the direction of the meridian, but for that purpose a more or less accurate knowledge of time, latitude and longitude, are necessary. Consequently, in the little book before us considerable space is devoted to the subject of azimuth—five methods for determining that quantity being given—and a comparatively small space to each of the other subjects. The Canadian engineer, practising in a country where large tracts of land are yet unexplored, may feel that even in an elementary work on field astronomy more space should be devoted to methods for finding geographical positions, and that it might therefore with advantage include the methods of determining time by an observed altitude, latitude by circum-meridian altitudes, and longitude by lunar observations. Notwithstanding the small compass of the book, however, Professor Holt has devoted ample space to fundamental principles. The subject of time, which presents so many difficulties to the beginner, is very fully treated; also the astronomical triangle, with the various problems related thereto. A chapter is devoted to spherical trigonometry in which is derived the formulæ required in the solution of the astronomical triangle. At the end of the book several useful tables are given, among which may be especially mentioned those for facilitating observations of the pole star for azimuth. A series of examples worked out in full serve to show the application of the methods described in the text and to give forms for computation. This little book may confidently be recommended to the busy engineer who has little time to devote to this subject.

Azimuth. By George L. Hosmer, Associated Professor of Topographical Engineering, Massachusetts Institute of Technology. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. Second edition, revised, 1916. 73 pages, 19 tables, 4½ x 7¼ ins., leather. Price, $1 net. (Reviewed by J. L. Rannie, D.T.S., International Boundary Surveys, Ottawa.)

The subject of azimuth has here been presented in such a manner "that a person who is unfamiliar with astronomy will be able to apply these methods and obtain satisfactory results without taking the time to completely master the theory underlying the method used."

One prefers to believe that those in the engineering and surveying professions are not quite so desirous of avoiding a simple azimuth observation as the author indicates, especially in this country, where a great many engineers have had surveying experience in our western provinces. Nevertheless, methods and formulæ which we use only occasionally have a habit of slipping from our memory and the author has presented the subject in a manner admirably suited alike to the man unfamiliar with astronomy and to the one who has forgotten many of the small practical details of observation and computation. The book is especially desirable, on account of its compact form, for the use of the engineer who desires to observe only occasionally for azimuth and then only approximately and who does not wish to carry the more cumbersome Nautical Almanac.

The methods of observing and the computations involved are described for the following cases: (1) Azimuth by an observed altitude of the sun or star; (2) latitude by the sun at noon; (3) azimuth and latitude by observation on Polaris and another star; (4) meridian line by Polaris at culmination; (5) azimuth by Polaris at any time; (6) azimuth by Polaris at elongation; (7) azimuth by equal altitudes of sun or star.

Examples are given showing the manner of making and computing each method of observation.

The essential features of such a book are as follows and show that the author kept these constantly in mind: (1) The data are defined in simple and non-technical language. (2) The object and limitation of the various methods are well defined. (3) The text is liberally supplied with foot-notes which explain many small but essential details. (4) The formulæ are often written without the use of symbols. (5) The symbols used in the formulæ are few and simple. (6) The formulæ used are adapted to the use of as few tables as possible. (7) The tables are suitably curtailed to suit the required accuracy.

Altogether the author has well fulfilled his purpose of presenting a compact volume for use by the engineering profession.

Elementary Mathematics for Engineers. By Ernest H. Sprague, A.M.I.C.E. Published by Scott, Greenwood & Son, Ludgate, London, E.C. 244 pages, 101 diagrams, 5 x 7½ ins., cloth. Price, $1.00 net. (Reviewed by O. Holden, B.A.Sc., Hydro-Electric Power Commission of Ontario.)

This volume is one of "The Broadway Series of Engineering Handbooks" and deals, as the title suggests, only with the elementary part of mathematics. While the field covered is necessarily of wide range the fundamental principles of each subject are clearly set out and illustrative problems are given showing their application. To the practical engineer whose technical training has been meagre and also to the engineer whose work necessitates infrequent reference to the calculus, etc., this book will prove most helpful.

Engineering Applications of Higher Mathematics—Part V., Electrical Engineering. By V. Karapetoff. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. 65 pages, 5¼ x 8 ins., cloth. Price, 75c. net. (Reviewed by H. W. Price, University of Toronto.)

Engineers as a rule avoid mathematical books written by mathematicians because those gentlemen almost invariably interest themselves only in abstract manipulations. They rarely see the engineer's need of this type of machinery, which becomes valuable only when he has expertness in applying it to known facts and in physically translating calculated results.

The author of this little book is an engineer as well as a mathematician, and has the engineer's point of view.

The book contains six chapters, each including some general information, sample solutions, and problems in great variety with hints and guidance where necessary.

The variety of problems considered is much greater than the titles of chapters would suggest. Some are: Resistance of tapered conductors, leakage resistance of cable insulation; air-gap reluctance of induction motors, and of alternators with graded gap; the minimum weight of copper in branched distribution systems for given loads and voltage regulation, the size of conductors for minimum annual total operating cost of transmission lines; properties of long telegraph lines having considerable distributed leakage over insulators; problems relating to economical design of transformer windings, and of cores in which cross-section is less through the coils than in parts outside the coils; losses in laminated cores, etc., etc.

Those wishing assistance toward skill in applying mathematics to engineering problems will find in this book many suggestions and sample applications.

PUBLICATIONS RECEIVED.

Suggested Specifications for Concrete Floors.—A 10-page leaflet published by the Portland Cement Association, 111 West Washington Street, Chicago.

Public Road Mileage and Revenues in the New England States, 1914.—Bulletin No. 388 of the United States Department of Agriculture, Washington, D.C.

Vapor Pressures of Various Compounds at Low Temperatures.—Technical paper 142 of the Bureau of Mines, Department of the Interior, Washington, D.C., by G. A. Burrell and I. W. Robertson.

Investigations of Gravel for Road Surfacing.—By T. R. Agg. Bulletin 45, Engineering Experiment Station, Good Roads Section, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

The Tractive Resistance on Curves of a 28-Ton Electric Car.—By Edward C. Schmidt and Harold H. Dunn. Bulletin No. 92 of the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 25c.

Department of Mines.—Summary report of the Mines Branch, Department of Mines, Canada, for the calendar year ended December 31st, 1915. Price, 25c.

Public Road Mileage and Revenues in the United States, 1914.—Bulletin No. 390 of the United States Department of Agriculture, Washington, D.C., showing for each state total and surfaced mileage of public roads at the close of 1914, revenues for roads and bridges in 1914, state and local road and bridge bonds outstanding January 1st, 1915, and other related data.

Answers to Problems in Alternating-Current Electricity, first and second courses.—By W. H. Timbie and H. H. Higbie. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. 30 pages, 5 x 7¼ ins., paper cover. Price, 50c. net.

Sun Oils-Refining.—Fourth of a series of illustrated pamphlets issued by the Sun Co., 1428 South Penn Square, Philadelphia, Pa., on the progress and rapid growth of the oil industry.

Province of Quebec.—Municipal statistics for the year 1915.

The Carburization and Burning of Powdered Coal as a Fuel.—A paper read before the American Institute of Mining Engineers, Chicago Section, December 22, 1916, by Alonzo G. Kinyon, chief consultant, Board of Engineering Research in Power Generation in Steam Locomotives, of the Powdered Coal Engineering and Equipment Company, 1903 McCormick Building, Chicago.

The "Mechanical World" Pocket Diary and Year Book for 1917.—A collection of useful engineering notes, rules, tables and data published by Norman, Remington & Co., Baltimore, Md. 453 pages, illustrated, 4 x 6 ins., cloth. Price, 35c.

City Budget Facts, 1916.—An analysis of Toronto's budget for 1916, based upon the official estimates, rearranged by the Bureau of Municipal Research, 813-820 Traders' Bank Building, so as to show costs of services rendered and of things purchased.

Directory of Cement, Gypsum and Lime Manufacturers. Eleventh edition, 1917, corrected to January 1st, 1917. Compiled and published by The Cement Era, 538 South Clark Street, Chicago. 244 pages, 3 x 5 ins., leather. Price, $2.00.

Ontario Safety League.—Third annual report of the Ontario Safety League, Royal Bank Building Toronto, being a brief statement of the fire and accident prevention campaign conducted during the year 1916. R. B. Morley, secretary-treasurer.

National Safety Council.—Findings of the committee of fifty safety experts of the National Safety Council, Continental and Commercial Bank Building, Chicago, summed up in the council's leaflets entitled respectively, "Ladders," "Stairs and Stairways" and "Boiler Rooms."

CATALOGUES RECEIVED.

Cochrane Heaters for Steam Power Plants, as used in heating, metering and softening water for boiler feed and other purposes. Catalogue No. 710 issued by the Harrison Safety Boiler Works, Philadelphia, Pa. Contains 106 pages and is well illustrated.

Concrete Machines.—Miniature catalogue, 1917, of 48 pages, issued by the London Concrete Machinery Co., Limited, London, Ont., illustrating in condensed form the entire line they manufacture.

Motor Trucks of America.—Fifth edition of an annual book distributed gratuitously by the B. F. Goodrich Co., Akron, Ohio, illustrating and giving the specifications of over a hundred different makes of motor trucks.

Mesta Automatic Plate Valves.—Bulletin "D" issued by the Mesta Machine Co., Pittsburgh, Pa., describing the Mesta automatic plate valves (Iversen patent), which are being used in both new and re-built air and gas compressors, ammonia compressors, vacuum pumps and blowing engines.

Walschaert Valve Gear.—Bulletin No. 1018, issued by the American Locomotive Co., New York. Sixteen pages, nicely illustrated.

Editorial

UNPUBLISHED ENGINEERING STUDIES.

There must be a great deal of useful information available in municipal engineering departments which, for one reason or another, does not receive the publicity that it deserves.

Engineering departments, for instance, are constantly carrying on experiments, making studies, etc., which many engineers in similar departments would appreciate knowing about.

In many cases such investigations are too voluminous to be given space in the department's annual report which, for obvious reasons, must be limited in size.

The fact that the results of such studies are in many cases lost is not always due to the lack of a suitable medium for their presentation, but to the fact that those who could make them public and useful to the profession at large do not take the trouble to do so.

It is reasonable to assume that at some time or another engineering departments, at least in our larger cities, conduct correspondence with other municipal engineering departments for the purpose of ascertaining, if possible, what their experiences have been in the solving of specific engineering problems. Doubtless much correspondence of this kind goes on as between departments. There is surely a spirit of co-operation between the different engineering departments to insure team work in matters of this kind.

Is this interchange of experiences given as much publicity as it is entitled to? It is true they are used by the department preparing them and are filed away after they have served their immediate purpose, but is this enough?

The profession as a whole is seldom any better informed as a result of the investigations. There is surely some means by which such information can be made accessible to a larger number of engineers. The technical journals are constantly searching for just such matter, and such investigators will always find the engineering papers willing to give the facts adequate publicity.

METROPOLITAN WATER BOARD AND CHLORINATION.

It is interesting to note that in the last report on research work issued by Dr. Houston, of the Metropolitan Water Board of London, and which has recently come to hand, the admission is made that the substitution of chlorination for storage has been made with strikingly beneficial results.

When it is remembered that the local government board has always refused to sanction schemes involving the constant use of chlorine, in spite of the excellent results that have been obtained on this continent, this admission is rather significant.

Now that the city of London has demonstrated its general utility it is more than likely that the adoption of chlorination will become more general in the United Kingdom.

In the first part of the report referred to, which is the twelfth, the results of investigation as to the best relative positions of inlets and outlets in storage reservoirs are discussed and although no definite conclusions are reached, it is evident that Dr. Houston regards this as an important consideration and especially so when the period of storage is not very long. Some of the results show evidence of short circuiting, a factor which has been extensively studied in connection with some of the American supplies.

The most important part, however, of the report is contained in the section devoted to sterilization. Experiments are described which led to the elimination of one of the large storage reservoirs (Staines) and the substitution of chlorination therefor. This method of purification was apparently forced upon the board by the economic conditions caused by the war; the price of coal advanced to an unprecedented extent, and it became imperative, in the national interest, to reduce the consumption to the lowest possible limit. On May 1st, 1916, the 70 to 80 million gallons of water formerly pumped to the Staines reservoir were chlorinated and passed direct to the filtration plants. The storage reservoir usually reduced the excremental organisms by 90 per cent. and it was decided that the chlorination should effect an equal amount of purification if it were to be regarded as satisfactory. It was found that the dosage of 15 lbs. of bleach per million gallons (0.5 parts per million available chlorine) eliminated over 99 per cent. of the excremental organisms and produced a very satisfactory water for final treatment by the filters. In addition, an important collateral advantage was obtained in the shape of increased filter runs. The percentage reduction in the area of filter beds cleaned in 1916, as shown by this report (June to September), as compared with 1915, was as follows:—

	Percentage reduction.
Grand Junction (Hampton)	6
Grand Junction (Kew)	43
East London (Sunbury)	30
Kempton Park	33
West Middlesex	56
Unweighted average	33

This reduction is attributed to the retardation of algal growths by chlorination.

THE CONSULTING ENGINEER.

It is not so very long ago when it was the rule for a manufacturer who was not an engineer to confine his attention to the trade regarding which he was especially concerned and, when necessity arose, to call in an engineer to advise him as to the purchase of this or that piece of equipment. To-day, however, it is, except in the case of large corporations and public bodies, very frequently the custom for this same manufacturer, to a considerable extent at least, to depend upon his own judgment, aided by those who would sell him the apparatus he is looking for.

One cause for this condition of things is that everybody nowadays has, or thinks he has, a smattering of engineering knowledge which can reasonably be used. Then, again, many salesmen are sufficiently tactful to make what little knowledge they may possess appear to be much more important than it really is.

This does not necessarily mean that the buyer of engineering equipment is ignorant or that the salesman is intentionally endeavoring to sell an inferior article. The point is, is that article the best and at the same time the cheapest for the purpose for which it is required? The untrained buyer cannot know and there is just a danger that the seller consciously or unconsciously cannot but be biased in favor of his particular firm's production.

Circumstances alter cases. For example, there is a great difference between going into the market for a machine of standard design which by common experience has proved to be suitable for the work in hand, and inviting tenders for the supply of a hitherto unknown engineering device concerning the success of which there is but little common knowledge available.

Furthermore, distinction should be drawn between advice regarding design, preceding the actual carrying out of the work, and advice associated with inspection during construction.

One reason why the consulting engineer is not called in more frequently than he is appears to be a suspicion that he may be biased in favor of some particular firm, or class of machinery, or that his services may increase the ultimate cost of contract, or perhaps he may be unnecessarily meddlesome and officious. Such a suspicion is, of course, most unfair to the qualified man.

The task of the consulting engineer who has nothing to sell but his services is not by any means an easy one. His work requires knowledge beyond the ordinary, as it is essential that he have practical as well as theoretical knowledge. He must be tactful, businesslike, just to his client and beyond the suspicion of partisanship.

His qualifications are not merely technical, but moral and temperamental. Character plays, or should play, an important part and the most successful consultants, whether in law, or medicine, or engineering, are men of a certain rare type of mind.

A little knowledge may indeed prove to be a dangerous as well as very expensive thing for those who would too readily dispense with the services of a consulting engineer with a thorough theoretical and practical knowledge of the requirements of the case and who by his education, training and experience is qualified for the special work he is called upon to perform.

PERSONAL.

LEON SPOOR LANDERS has been appointed assistant engineer, Canadian Government Railways, Levis, Quebec.

WILLIAM BEDFORD HARPER has been appointed resident engineer of the Laurentian Division, Quebec District, C.P.R., Montreal.

THOMAS J. McALPINE, of Summerland, B.C., has been appointed road superintendent for the South Okanagan riding by the provincial government of British Columbia.

T. C. MacNABB, A.M.Can.Soc.C.E., formerly division engineer, C.P.R., at Moose Jaw, Sask., has been promoted to the position of superintendent at Revelstoke, British Columbia.

J. H. VICKERS, Vancouver, B.C., has been appointed superintendent of works on the Vancouver Joint Sewerage and Drainage Board's portion of the Stanley Park sewer outfall.

W. R. HARRIS, M.Can.Soc.C.E., has moved from Regina to Winnipeg to take charge of the contract awarded to the Canadian Lock-Joint Pipe Co. on the Greater Winnipeg Waterways.

THOMAS LINSEY CROSSLEY, A.M.Can.Soc.C.E., has just opened an office and laboratory at 43 Scott Street, Toronto, for J. T. Donald & Co., of Montreal. He will specialize in municipal chemistry.

J. W. B. BLACKMAN, M.Can.Soc.C.E., city engineer of New Westminster, B.C., has enlisted for overseas service and has been granted indefinite leave of absence by the city council. H. STEWARDSON, A.M.Can.Soc.C.E., assistant city engineer, has been appointed to act in his place.

R. E. CHADWICK, eastern manager of the Foundation Co., Limited, has just returned to Montreal after an extensive western tour, having visited Seattle, Vancouver and the Pacific Coast generally; Winnipeg, Port Arthur, Sault Ste. Marie, and practically all portions of Canada west of Montreal.

Major JAMES A. DeLANCEY, of the engineering and surveying firm of Lighthall & DeLancey, Vancouver, B.C., has been awarded the Military Cross. He had been thrice promoted for meritorious actions since September, 1915, and was mentioned by General Haig in despatches after the Ypres engagement on June 3rd.

O. W. MEISSNER, M.E., has removed from Commissioners Street West to St. Antoine Street, Montreal. He represents a number of firms making railway, steel, and machinery supplies, is a special agent of the West Coast Pipe Company, Limited, Vancouver, patentee of the O.W.M. air track sander system, and president of the Steel Specialties for Canada, Limited.

J. H. CHOWN has been appointed superintendent of the Regina division of the C.P.R., to succeed J. K. SAVAGE, who has been transferred to the eastern division. M. McKAY, formerly superintendent of the Revelstoke division, has been appointed superintendent of the Saskatoon division, and T. C. McNAB, division engineer of the Saskatchewan division, has been appointed superintendent of the Revelstoke division.

OBITUARY.

THOMAS SCANE, C.E., one of the oldest land surveyors and engineers in the province of Ontario, passed away on February 9th at his home in Ridgetown. Deceased, who was in his 83rd year, was born in Howard township, and was township engineer of Howard and Orford townships for many years.

JOHN STOCKS, a member of the Alberta Provincial Utilities Commission, died suddenly at Edmonton on