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Volume 21. Toronto, July 13, 1911 Contents of this issue on page 45

The Canadian Engineer

An Engineering Weekly.

CAUSES OF DETERIORATION OF BOILERS.*

By C. C. Nelson.

Boilers were once considered of only secondary importance to the majority of marine engineers, but lately it has become the practice to study the boilers more, and they now rank in the first place of importance, so that it is essential that they be kept in good order. To do this requires the knowledge of the causes of deterioration, of which causes the principal is corrosion. Water at ordinary temperature (60° F.) and under normal pressure (14.7 lb.) dissolves its own vol. of CO_2, but a change either in temperature of water or pressure of atmosphere will be accompanied by a change in the quantity of gas dissolved; so that if temperature of water is increased the water gives off gas, but should the pressure be increased the water will absorb more gas. This is the reason that heating the feed water tends to preserve the boilers. And it also shows the advantage of heating the feed water (up to about 200° F. under atmospheric pressure) before putting it under pressure. The carbon dioxide that gets into the boilers can be completely absorbed by the addition of sodic or potassic hydrate. The CO_2 unites with alkaline hydrate forming a carbonate and liberating water.

Sodic hydrate + Carbon dioxide = Sodic carbonate + Water

$$2NaHO + CO_2 = Na_2CO_3 + H_2O.$$

Corrosion may be caused by the oxidization of the steel by acidulated boiler water, and by electro-galvanic and thermo-galvanic action. The most fruitful of these is rusting, which is directly caused by the carbonic gas (CO_2). This is present both in the air and water and enters into combination with the iron or steel and forms carbonate of iron, which in turn absorbs oxygen, and the final product is oxide of iron (Fe_2O_3). This thin coating would preserve the iron, only unfortunately in this last change the original particles of the CO_2 are liberated and in turn attack the plate and so the cycle continues. Dry pure oxygen alone will not exert any action on iron or steel, neither will CO_2 while dry, but the two together in the presence of moisture set up rapid corrosion.

While rusting may take place anywhere inside a boiler it is often in evidence at the water level on the shell plates, as at this place the washing about of the water alternately wets and dries the plate, which is the exact state iron and steel need to be in to facilitate heavy rusting. The excessive difference of temperature at the line of fire bars tends to set up thermo-galvanic action, to which is assigned the pitting found here, but some authorities state that this pitting is caused by small air bubbles which cling to the sides of vertical heating surfaces; the period that these small bubbles rest on a plate is long enough for the oxygen they contain to act on the iron or steel and cause small irregularities, on which subsequent bubbles find a still better lodgment, and speedily effect the formation of pitting. The straining of the plates, as at the line of fire bars, loosens the rust and the pitting gradually gets deeper. Mr. Macfarlane Gray's idea of pitting was that it was caused by minute particles of copper, but this was questioned by another authority, who stated that he had found pitting in land boilers, in which there could be no question of copper at all.

Acidulated Boiler Water.—It seems to be generally accepted that boiler water, when using a surface condenser, after a time becomes acidulated, even if the supplementary feed is obtained by means of an evaporator; there are many theories advanced to account for it, but none seem to be universally accepted, though I think the idea that hot water is in itself a solvent, carries some weight; but having the acid in the water, the best thing to do is to remedy it by using an alkali, preferably carbonate of soda, or caustic lime, in fact it is advisable to keep the boiler water slightly alkaline. The use of only hydrocarbon oils for internal lubrication of the engines prevents acids from oil forming in the boiler, as it takes a temperature of about 700° F. to decompose these oils, while animal and vegetable oils decompose at about 270° F., and form stearic and oleic acids respectively, besides their own particular acid due to the base they come from.

Sea water contains many salts injurious to iron and steel, but we must take into consideration the different behavior of salts at the conditions present in boilers with steam up. Sea water put into a boiler will, when heated, deposit Calcic sulphate, at a temperature of about 300° F., which forms an insoluble skin and prevents the injurious action of the other salts. But continual feeding with salt water would increase the thickness of this skin, and in time cause overheating of the plates, etc., owing to its non-conductive properties. Sea water fed into boilers previously containing fresh water will probably, other conditions being favorable, cause corrosion on the same principle that dilute nitric acid will eat right through a leaden vessel, while strong nitric acid will not affect it further than forming a coating of nitrate of lead which prevents the further action of the acid. Chloride of magnesia is always present in sea water, and is exceedingly injurious; it will attack iron or steel with or without the presence of air at about 212° F., while the following chlorides only attack in the presence of air. They are here arranged in the order of their corrosive power:—Ammonium, Sodium, Potassium, Barium and Calcium. Chloride of magnesia will, under certain conditions, decompose and form hydro-chloric acid, which is also highly injurious to iron and steel, but although some authorities quote this as being one of the causes of corrosion in boilers it is a fallacy, as to cause decomposition of magnesium chloride it has to be heated to dryness at not less than about 300° F., and this dryness cannot be obtained when in contact with saturated steam: the only way it could happen would be by the salt water being carried into the super-heater by priming.

Copper salts seem to be a constituent of nearly all feed water; its effects may be seen as green scale on or near the zinc plates. For some unaccountable reason, it does not deposit itself uniformly over the boiler, but only in spots—chiefly non-heating surfaces. The origin of copper salts in boiler water is supposed to be from particles carried in with the feed water, and also that the distilled water acts on copper as a solvent.

*Paper read before the Institute of Marine Engineers.

Zinc salts act as a preservative in boilers, and the painting of the whole of the interior of a boiler with zinc oxide, and the addition of some zinc salts (the chlorides excepted) to the boiler water, has been proved to be beneficial.

Mercury salts are known to be an efficient protector against rust, and the only reason against their use I can find is excessive cost.

Alkalis.—In some ships slacked lime, caustic potash, soda, or their carbonates, is sometimes added to neutralize any free acid in the water. If added in excess it may do harm, the lime forming as a sediment on the heating surfaces, and the soda eroding the spigots, etc., of the brass valves, and if copper pipes are used in the boiler, galvanic action may be set up. When an alkaline or basic compound is brought into contact with an acid compound the H of the acid and the metal of the base exchange positions and form a salt as:—

Sulphuric acid (H_2SO_4) + Caustic soda ($2NaOH$)
= Sulphate of soda ($NaSO_4$) + Water ($2H_2O$)

An alkali also has the power of absorbing and neutralizing Carbon dioxide (CO_2).

Anti-Incrustators.—Of these Sodic carbonate, in one form or another, generally plays the principal part; its action is to convert the calcic sulphate and magnesic chloride into carbonates.

Calcic Sulphate		Sodic Carbonate		Calcic Carbonate		Sodic Sulphate
$CaSO_4$	+	Na_2CO_3	=	$CaCO_3$	+	Na_2SO_4

The hardening effect of the calcic sulphate being done away with and the calcic carbonate precipitated in a soft condition, when it can be blown out. Ammonic chloride is also sometimes used, and when boiled in presence of calcic carbonate decomposes it, forming soluble calcic chloride whilst the ammonic carbonate volatilizes.

Whenever there is any doubt as to the harmlessness of fluids or salts intended to be put into a boiler, it is better to test them as follows:—Boil them and then put a clean knife blade into the liquid: should rust be formed, should the water be discolored or should copper deposit itself on the blade, then the substance should not be used. If certain free acids are present, the above test will give no warning, but a few drops of prussiate of potash should be added, when, if steel is being dissolved a light bluish precipitate is at once formed which slowly turns dark blue, or if tannic acid be added, a substance like ink will be formed. Salt in the water can be found by putting a few drops of nitrate of silver in a glass of boiler water, when the contents will become cloudy.

The Behavior of Hydro-Carbon Oils in Boilers.—Filters should be used for feed water to arrest solids and oils, principally oils, for once the oil gets into the boiler the globules, if in sufficient quantity, coalesce, forming an oily scum on the surface of the water, but if present in smaller quantities remain as separate drops; these drops show no tendency to sink as their specific gravity is about .889, but they gradually come in contact with the minute particles of calcic sulphate and other solids separating them from the water and in time covering them with oil, which enables them to stick to any surface they come in contact with. The S.G. of the particles will increase as they become more and more loaded with the solids, till a point is reached, at which they have the same specific gravity as the water, and they now rise and fall with the convection currents of the water, attaching themselves to the surfaces they come in contact with, the position on the surfaces depending on whether they come in contact whilst descending or ascending. This deposit is a non-conductor of heat, and also from its oily nature it tends to prevent intimate contact between itself and the water. On heating surfaces this leads to overheating of the plates, and the deposit begins to decompose by the heat, the lower layer in contact with the plate giving off gases which blow the greasy layer, ordinarily about 1-64 in. thick, up to a spongy leathery mass often ⅛ in. thick, which, owing to its porosity, is now even a better non-conductor than before; the plate becomes heated to redness and being unable to withstand the pressure of steam collapses.

During the last stages of this overheating, however, the temperature has risen to such a point that the organic matter, oil, etc., present in the deposit, burns away, or more properly speaking is distilled off, leaving behind as an apparently harmless deposit the solid particles round which the oil had originally formed.

Impurities in the Metal.—The composition of boiler plates often has a great deal to do with corrosion in boilers. In a ship built in the north of England, her boilers lasted only months, when, notwithstanding that all preventives and preservatives were tried the boilers were condemned by the B.O.T., and new ones had to be put in. I should think that is a case where there were some injurious impurities in the steel. The steel used for boiler plates is generally that produced by the acid Siemen Martin's regenerative furnace process, as its composition can be regulated better than by any other method for the same cost. The heat in this furnace is produced by a gas, mixed with air, generally coal or water gas, and it is assumed that the metal occludes some of the components of the gas, such as carbonic gas, hydrogen, etc., and that in cooling it gives most of them off again, but should any injurious substance remain it is often the cause of rapid corrosion, and this may have been the cause of the trouble in the above-mentioned boilers. Pickling the plates has been tried with partial success, though it is said to reduce the elongation about 15 per cent., and the ductility about 40 per cent.; this can be rectified by annealing, but it is a question whether the plates will not return to their former state after being in the annealing furnace. It was found on analysing steel that had been galvanized, that it had occluded from .002 per cent. to .005 per cent. of hydrogen, and taking into consideration the low atomic weight of hydrogen, these percentages should be multiplied by 32 and 31 respectively to make them comparable with the volumes of sulphur or phosphorus. This goes to prove that under certain conditions the occlusion of gases by metals does take place.

Galvanic Action.—I think that there is room for a great deal more knowledge of this; even at the present time it is often the practice to blame it for certain peculiarities of corrosion, when nothing else will explain it. The theory of galvanic action is most lucidly explained as follows:—"When two metals of dissimilar nature are immersed in a liquid capable of chemically acting on both of them, and are connected, or are in metallic contact, then that which is the more easily corroded becomes the positive element or anode, while the other metal becomes the negative element or cathode." The impurities in steel with an electrolyte in contact will cause galvanic action. The electrolyte in the case of a boiler is acidulated or alkaline boiler water. Another form of electro-galvanic action is that between different materials, as in the steel shells and iron tubes (steel tubes are used in the British Navy, but iron are still mostly used in the Merchant Service). Zinc is put into boilers to prevent corrosion, and does it, but zinc put into boilers to absorb galvanic action is a fallacy and the polishing of the contacts as is often insisted on, is a waste of time. Supposing that the boiler is just newly closed up, and the zinc plates are in perfect metallic contact with the metal of the boiler, how long is it likely that the surfaces will remain perfectly bright?—possibly half an hour—when a thin skin forms, and taking into consideration the weakness of the electrolyte (boiler water is never a strong electrolyte in practice), all current stops; though I am afraid that after the years it has been accepted, all discussion on this point will not stop here. Another reason that causes me to think that zinc plates do not continue to act as the positive element in a boiler, is that you never find zinc deposits on the steel of the boiler, which should happen if zinc was the anode and steel the cathode. I expect some of the members are wondering how I account for the wasting away of the zinc; well I think this can be explained as follows: Hot water acts as a solvent on zinc and the oxygen in the water chemically combines with the zinc forming zinc-oxide.

Zinc		Oxygen		Zinc-oxide
Zn	+	O	=	ZnO.

It is worth noticing that, when two dissimilar metals are immersed in a liquid capable of chemically acting on them both, but not connected, they both corrode; connect them as shown in diagram, and as soon as current flows, one is eaten away while the other is preserved. I have an idea that galvanic action might be made to preserve the boilers, for we know that if two plates of similar nature be immersed in two separate vessels, and a current made to pass from one plate to the other through the liquid, then the one the current leaves becomes corroded, while the other is preserved.

Let A and B be two vessels each containing the same kind of electrolyte, and let C and D be two plates of steel and E and F two plates of carbon, which is non-corrodible, then the current leaving the battery passes through C into and through the leectrolyte into E, then into F, through the electrolyte in B and into D, thence back to the terminal of battery; here the plate C will become corroded. Surely this is a field which would amply repay investigation by those interested in galvanic action in boilers.

There is another action set up in boilers called thermo-galvanic action; this is caused by unequal heat in the plates, even though it is the same plate, and of the same material; one of the principal places where this takes place is on the sides of the furnace tubes about the line of fire bars; but I do not think this action exerts much influence in the corrosion of boilers. The action of stray electric currents is blamed for a great deal more than it deserves, and personally, the only defect I can see this will cause, is the eroding of copper feed pipes.

Another and important factor in deterioration of boilers is faulty construction, and bad workmanship in working plates, etc. When a boiler structure is so combined that certain parts are kept in a state of restlessness, either difference of expansion and contraction, or any movement causing alternate strains, then, all such restlessness tends to wear out the parts thus exposed, not so much by the mere friction as by the process of disintegration, whereby the incipient oxide is prematurely scaled from the surface of the plates, and causes what is known as grooving. This restlessness also causes fatigue and shows as brittleness in the plate. If a boiler is so constructed as to have a tendency to restrict circulation, it may give trouble. This has been known in a boiler that had too little space over the furnaces, to so overheat the crowns as to cause them to collapse; such was the case in an Atlantic steamer, where the crowns came down nearly every trip. At first the owners tried to remedy this by discharging the engineers, but finally remedied it by drawing the row of tubes above the furnace. Restricted circulation causes the heating surfaces to become hotter than they otherwise would, and it is a recognized fact that acids will attack the hottest part of the plates. Methods of working the plates such as local heating, flanging and working at a blue heat, often cause cracks, etc. It has been found by experience that between 450° and 550° F. (known as blue heat) steel appears to become rotten, though above or below this temperature it may stand bending or other tests. I think the usual methods of annealing plates leave much to be desired.

Scale.—Always keep scale from accumulating on tubes, especially round the necks, as apart from the loss of economy, it causes leaky tubes, and I suppose nearly all members here remember the pleasant task that at some time or other has been theirs in the back ends. But it is seldom explained why thick scale round the necks of the tubes causes the tube ends to leak; it has been told me that they overheat, and the expansion and contraction causes it, but it always seemed to me that it was rather vague, till on further considering it I have come to the following conclusion: before tubes are put into a boiler they are annealed, then on expanding a certain action takes place in the metal, resembling, if not, tempering it, which gives it elasticity. Supposing the tube ends are overheated through the heat not passing away to the water rapidly enough, caused by thick scale, then the ends become annealed again, and it may be noted that often the tubes do not leak till a change of temperature takes place, as from a lower to a higher, such as lighting up fires again; this leaking is caused by the tube ends not now possessing that requisite elasticity to follow up the longitudinal and compressive strains in the tube and the strains in the tube holes. This is remedied by re-expanding, and thus giving the metal elasticity again.

I would like to mention before I finish this paper, a case in which corrosion resisted the efforts of the engineers, until they boiled the boiler out for twenty-four hours with caustic soda. This would generally be thought to be a rather drastic treatment, but it was so effective that they were not troubled with corrosion again, though even after several "washings out" with fresh water before closing up, the boilers were inclined to prime when they first "got away." Another case that happened was this: the boilers when opened were found in excellent condition, they were brushed down and then washed out with sea water. A delay occurred so that the fresh water was not put in until two days later; then, when the engineer went to have a final look round, he found that the backs of the combustion chambers were bleeding: this was remedied by painting with white zinc and kerosene.

If you are in charge of boilers in good condition, I would recommend the following:—See that steam is raised slowly, and that the water is kept circulating when raising steam, keep boiler water slightly alkaline, scum and blow frequently—by scumming you get rid of grease, etc., and acid, though at the expense of the freshest water in the boiler; by blowing you get rid of sediment and denser water. When blowing do not let vibration take place any more than is possible, and do not blow at less than 53 lb. gauge pressure or 300° F., since water as it cools will resume the sediment to its full carrying capacity. And always avoid shock action in a boiler.

After trespassing so long on you patience, I will not further enumerate the many other things relative to boilers. I am leaving them for the other members to bring forward at the discussion to follow, which is the reason of my attempting this paper, as I think this an excellent opportunity to get the opinions of experienced engineers.

INCREASED BRAKING POWER FOR FREIGHT CARS.*

John P. Kelly.

Ever since continuous power brakes have been employed to control the motion of freight trains, the amount of braking power that should be used has been much a matter of individual opinion. It has been the custom since 1887, the date of the famous Burlington brake trials, to make the braking power equal 70% of the light weight of the car, using a cylinder pressure of 50 pounds per sq. in. from which to base the calculation.

To be able to control a freight train, wholly equipped with continuous power brakes, which could be operated easily from the locomotive, even when the maximum power capable of development by the brakes was only 70% of the light weight of the car, was such a vast improvement over what had hitherto been possible of accomplishment in the way of control with the hand brakes by even the most active crew of brakemen, that we need not be surprised that no energetic demand on the part of the railways has ever been made since, for increasing that percentage. But the conditions existing at present have brought the freight equipment to a point where some change in the percentage of braking power should be made.

I should consider that a braking power of 35% of the loaded weight of a freight car, based on a cylinder pressure of 50 lbs. would constitute an adequate power, and anything less than this inadequate. I consider this braking power adequate because, with the simplest type of automatic air brake apparatus, I should be able to take a loaded train down our longest and steepest grades in safety and (with few exceptions) without the use of pressure retainers.

Up to comparatively recent years the chief consideration for the limitations on the percentage of brake power that should be employed on freight cars has been that of the supposed danger to the wheels from sliding flat, rates of retardation in different parts of the train and the shocks resulting therefrom not being considered, probably for the reason that with the shorter trains the effects of these were not so pronounced and therefore not so likely to be noticed as they are to-day in our much longer trains.

Few who are familiar with this phase of the question now believe the wheels are in any danger from sliding flat, due to the braking pressure alone, however much may be applied to them, if all the wheels in the train are impressed with the proper amount of shoe pressure. Pressure alone cannot cause them to slide flat, but numerous other conditions which tend to produce wheel sliding must be present and active to cause them to slide while being acted upon by the brakes. Again, the length of the flat spot produced on the sliding wheel is in turn dependent on the weight that the wheel is carrying at the time, the condition of the rail (whether wet, dry or sandy), and somewhat on the kind of metal in the wheel, as well as largely on the inequality of distribution of braking power in the whole train.

Therefore, I do not anticipate any very decided opposition to my plea for an increase in the percentage of braking power now generally employed on freight cars to something quite beyond what some of us may deem practical, on the ground of any fear of what may happen to the wheels. But to my mind the objections that will be raised will come from a serious consideration of what effect a braking power of 120% of the light weight of each car (about 35% loaded weight) would have in a train of 100 or more cars, all braking at this percentage, when they were wholly loaded or wholly unloaded, part loads and part empties, whether running at 10 or at 40 m.p.h., with either a service or an emergency application.

When brakes are applied on a long train, whether in service or in emergency, some shock of more or less severity as a general thing results on the rear. Even when no brakes are applied and a very long train is drifting into a curve, the resistance produced by the curve on the forward portion of the train is sufficient to cause well pronounced shocks at the rear; it may be light, as it sometimes is, or it may be extremely severe.

Now, whether the shock be light or heavy, our long trains are subject to another danger coming from what we term the "internal pressure" which acts during the progress of an application of the brakes either in a service or in an emergency, and which becomes sometimes great enough to cause the train to buckle and force cars upon which the enormous pressure acts to move out sideways from the track.

The buckling of our long trains is a serious matter, even now while we are using only 70% braking power, although as equipment of steel construction increases this danger diminishes. But any change that we are to consider, either in braking power employed or method of handling the brakes, must be with a view always to lessening the chance for damage in effecting stops. In short, it should be possible for the brakes to apply from any cause, either in service or in emergency, without danger of heavy shock or damage.

Even with the automatic coupler there yet remains considerable slack in our long trains that makes itself felt more or less strenuously whenever the brakes are applied in emergency, so that, while we desire to give full credit to the air brake for all that it does, yet it is only fair to the coupler to give it credit for making possible the degree of success thus far attained by the air brake in operating without destructive shocks. But the amount of slack is yet so great that it must be considered in connection with any scheme of braking that may be proposed.

How are we to increase our braking power without at the same time increasing the danger of shock under all conditions of train make-up? To answer this question fully would require considerable space, but we may say that with every considerable increase made in the percentage of brake power employed we immediately reduce the probable number of emergency applications that will be required, and this in itself is a very great gain.

The consideration of the lessening of the time to complete a stop where the higher braking power is employed will, I am sure, lead to the conclusion that it can be successfully employed on trains that are composed entirely of empty cars or on trains composed partly of loaded and partly of empty cars, while as to its successful operation on trains composed entirely of loaded cars it seems to me there can hardly be any question.

With all things in good condition, a fairly short stop may be made in emergency on level grade with the present 70% of the light weight. But even here we find conditions such in fast freight service that a more powerful brake is very desirable. In fact, where such fast freight trains are run on a fast schedule and following passenger trains, the brake should be powerful enough to stop them in distances equally short from the speed at which they are run as passenger trains can be stopped from their average higher speeds.

When an emergency arises due to carelessness or oversight on the part of the engineman in charge of the freight train in observing signals, or in case of short flagging on the part of the flagman on a preceding train, a quick and

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*Abstract of a paper read at the annual meeting of the Air Brake Association, at Chicago.

powerful brake can save a lot of trouble and, in many cases, life as well as property.

But when we come to consider heavy grade work where trains of heavy capacity cars are handled, and these with the usual 10% overload, the higher braking power will be of great advantage. On a 4% grade the proportion of the total weight tending to accelerate motion down the grade is 4% of the load or total weight of the car. Taking a car whose total weight is 150,000 lbs., the accelerating force is 6,000 lbs., and to neutralize this force a retarding force of 6,000 lbs. must be exerted. Where the total brake force on such a car is but 70% of the light weight, (based on a 60-lb. cylinder pressure, the car weighing 40,000 lbs.), we have a total brake force of 28,000 lbs., and from this force we can count on from 15 to 18% of it as the retarding force, or from 5,200 to 4,640 lbs. I have not considered resistance due to flange, journal and curves, friction nor losses in braking power chargeable to the foundation gear.

Evidently here is a case where we must have more retarding power if we are to control the motion of the car, for the force of gravity equals 6,000 lbs., and the braking power or retarding power must be greater than this to control the motion.

Taking the braking power at 120% of the light weight, or 48,000 lbs., we should then have a retarding power of from 7,200 lbs. to 8,640 lbs. In addition to this, if we increase the brake pipe and reservoir pressure from 70 to 90 or 100 lbs., we have a brake which is capable of handling the train safely with a reasonable margin of safety on a grade of 4%. On all lesser grades, unless they were very long, it would be quite possible to handle trains on them without the aid of pressure-retaining valves. This would be very desirable for several reasons, among them the avoidance of the necessity for trainmen to go over the train to operate them and the prevention of the slid flat and hot wheels that are chargeable to their use.

We have now mentioned some of the advantages to be sure, and these are mixed in trains with other cars braking power, or better, to 35% of the loaded weight. But would not this cause some terrific shocks on the 100-car train on level grades? I do not think so, and for the following very good reasons: The shock and internal pressure which causes buckling is not due so much to the amount of braking power as to the manner and time in which it acts. I should expect the higher braking power to accomplish a much smoother stop so far as shock in the rear is concerned. In an emergency application on a train of empty cars, would not the braking power be so heavy as to slide and flatten all wheels? I should say there will be no flat wheels; whether any will slide or not will depend on how fast the train is going at the time the application is made, and in this case it should be borne in mind that unless the speed is very high the cause for the emergency will have to be very close and sudden, else a service application, with the high braking power, will suffice to bring the train to a stop. In any case, however, there will be no slid flat wheels, as the empty car does not impress sufficient weight on the wheel to cause it to flatten, unless slid several thousand feet.

But how about the mixed load and empty train, say consisting of about 35 loads and 65 empties, will they break in two when the brakes are applied either in service or emergency application? And I answer "No," for good and sufficient reasons.

It is my belief, however, that if the higher braking power for freight cars should receive any attention the time of equalization between the auxiliaries and the brake cylinders should be increased so as to permit the rear brake on a 100-car train to commence to apply before the first brake is fully applied. This would increase the flexibility of the brakes both in service and in emergency applications, and no heavier brake gear would be needed to be employed than is now the case with the 70% brake.

We find cars now running that are braked at nearly 100% of their light weight, based on 60 lbs. cylinder pressure, and these are mixed in trains with other cars braking as low as 60% and having ordinary quick action triples. Yet these conditions are being got along with fairly well. How much better, then, would matters be if the loaded weight of the car was used as the base on which to fix the braking power, if the percentage determined upon were 35% or more, as experiment might show could be successfully used.

With braking power of the percentage given, based as recommended above, a proper regulation of the flow of air into the brake cylinder, as well as quick serial reduction in brake pipe pressure, will in my judgment improve conditions in freight service to such extent that runaways on grades will never be heard of again, and shock and break-in-two on our long trains will almost if not entirely, disappear, while many of the cases now requiring an emergency application to stop in time to prevent accident will then require only a service application.

AIR TIDES.

Lawrence Hodges in a paper before an English scientific body gave some unique facts about air tides which are not generally known.

The moon causes the marine tides by its attraction. It draws the water on the surface of the earth toward it in a hump on the side that is exposed toward the lunar influence.

The air, it seems, is affected in the same way. The layer of atmosphere about the earth rises, falls and flows more freely than water, so the tide comes more quickly in the air at a given spot than the marine tide.

This rise and fall, however, means just as much to the navigator of the air as the tide in the sea does to the sailor, and has to be accounted for. The most remarkable current, however, is one constant stream in the atmosphere running from west to east completely around the earth in the upper atmosphere.

This was first brought to public attention when the Volcano Krakatao blew a cubic mile of matter into the upper atmosphere in the eighties. The lighter particles were seen to make a complete circuit of the earth seven times in this circumglobular current before they finally disappeared

STEEL PRODUCTION OF LEADING COUNTRIES.

	United States.	Germany.	Gt. Britain.
Converter:			
Acid	9,563,376	171,108	1,156,313
Basic	....	8,030,571	651,268
Open-hearth:			
Acid	1,231,575	252,148	2,695,482
Basic	15,537,006	5,125,421	1,603,793
Crucible	124,260	83,202	....
Electric, etc.	56,220	36,188	....
Total	26,512,437	13,698,638	6,106,856
Prop. steel to pig iron.	95.6	92.6	58.8

ENGINEERING AS AN ECONOMIC SCIENCE.*

This history of engineering as an industrial art is the history of the economic development of civilization; economic, as distinct from normal and social progress. In general, engineering has not been called into play to accomplish a final object that could not have been achieved somehow without engineering, for nearly all things are possible, given enough labor and time. The superiority of our present day engineering in such construction as that of the Great Pyramid of Egypt would lie rather in the economy of labor than in the intrinsic result as a tombstone.

Various measurements on the Great Pyramid have given the height divided into twice the base as equal to five decimal places, which accords fairly well with what we would be likely to attempt by way of a monumental "stunt" to-day, yet to duplicate the work by modern methods would probably require much fewer actual man-days of work than in the time of the Pharaohs.

The printing press for the cheap communication of ideas, the railroad for cheap transportation, and the steam shovel, the rock drill, and the concrete mixer, having given us improvements in method, which affect the possible quantity of result per unit of labor, rather than the ultimate nature of that result itself.

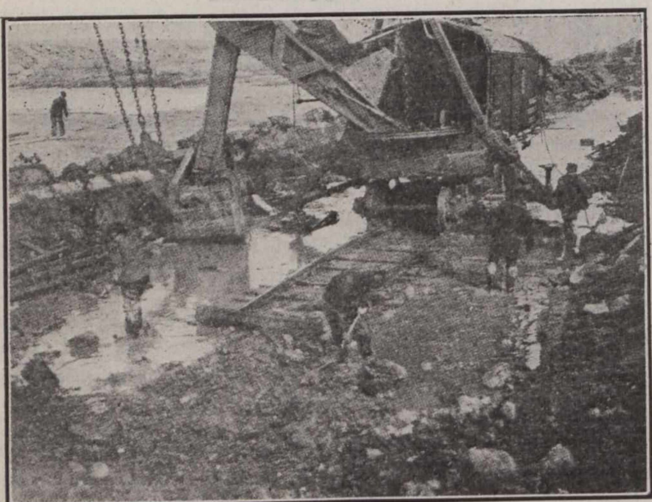


Fig. 1.—Steam Shovel Work Made More Expensive by Frost.

We can mix concrete on a board, and communicate our thoughts to our friends in long hand, and the concrete will be just as strong, the thoughts just as logical as though we employed modern methods, the only essential difference being the quantity or magnitude of the result per unit of labor and of time. This conservation of labor and of time by scientific methods is the true inwardness of engineering, and its present position with reference to the art of construction is the subject of this paper.

The contractor is interested in engineering as a means of getting the maximum pay with the minimum expense; to help him to obtain from his men the maximum result per dollars, and to guarantee to him a fair estimate. The economic value of the engineer's work is the only one that he can recognize, and he cannot always recognize that.

To erect a bridge over a given stream is entirely possible without an engineer, since bridges, and good ones, were built thousands of years before engineering developed, but to-day the bridge contractor knows that cutting, punching, riveting and minor assembling in the shop is far less expensive than at the site of the work, and that, furthermore, simultaneous operation on the many details of one structure is cheaper than its consecutive development; so he employs engineering as the only means by which he can secure simultaneous operation of a multitude of details and assure himself of a perfect fit; the minimum waste of material and labor; the lowest cost. He needs engineering to co-operate his labor and to assemble his materials to save time to himself and to others, and for no other reason, since the cost of material is in the last analysis, the cost of the time per man required to get it out.

Material alone has little or no intrinsic value, diamonds costing more than coal because they are harder to find. Into whatsoever branch of the subject we extend an investigation we find the same rule to apply, namely, that the economic development of evolution of every industry is in the direction of the conservation of labor by methods which tend to become more and more exact.

The application of the methods of exact science to the problems of construction has done more towards this conservation of labor than all other causes combined, and no effort is likely to accomplish more in the future of this field than that which endeavors to bring into scientific order the facts that can be collated and that bear upon this same question of the conservation of labor; the effort—to borrow a bucolic phrase—to make two blades of grass grow where one grew before.

The carrying out of the design the construction in the field, the delivery of the goods under the present economic system is the particular care of the contractor, who necessarily becomes the financial expert to carry on the work. His success is dependent upon his knowledge of the true economic conditions of labor and material, and he must so conduct his operation as to produce the result required by his contract at the least cost to himself; in addition to which he must guarantee the efficient performance of his work up to a sum of money which is often many times in excess of his entire available capital. If he fail in his accurate estimate of what it ought to cost for construction, if he fail to live up to his estimate of what he himself can accomplish, or if, through accident or unforseen conditions, he be unable to make good on his guarantee, he must bear the loss and take it out of his previous savings.

It is worthy of note that in this feature contracting is practically an insurance business in which the ratio of individual risk to capital employed is enormous compared with the similar risk in the fire insurance or life insurance business. A life insurance company reckons with the average of millions of cases, the contractor reckons with the average of dozens.

From the point of view of present-day practice, engineering resolves itself into engineering design and engineering construction, and under these two classifications will be found a convenient method of investigating it.

The cost of construction, as distinct from design, the structure having been planned and specified, will include the following factors:—

The magnitude of the work.

The necessary amount of capital in proportion to the contractor's resources.

The nature and condition of the available equipment.

The efficiency of his managerial organization.

The general layout of the work.

The labor market.

Material.

The nature of the materials, whether in stock sizes and of such quality as to be easily worked.

*Extracts and discussion from a paper by Richard T. Dana, read at the regular monthly meeting of the American Society of Engineering Contractors.

The probable interference from trains.

The necessary speed with which the work must be conducted.

The weather.

The engineer or the contractor of experience will readily supply his own commentaries to the various items which I have enumerated and he can furnish many more items that have not been mentioned, and I believe in every case, except that of the strength of steel, he will come to the conclusion that "judgment," that elusive quality of experience, rather than scientific rule, must be applied in order to obtain the quotient of the fraction $\frac{\text{Minimum Cost}}{\text{Actual Cost}}$ until after the word has been completed and the damage has been done.

Taking each item by itself, an independent study of it is vital to the contractor's interest, yet how seldom is he in position to make such study when the cost of the expert work, except in large operations, may be in excess of the probable saving which the study may make possible?

In such case the activities of this society may be of inestimable value to its members, since through the Journal the data for the necessary inductions may be exchanged, and rules of economic practice, far in advance of anything as yet available to construction men, may be placed at the disposal of the contractor, the owner and the engineer.

The Discussion.

The discussion that followed this paper was largely in connection with several views showing faulty methods in construction work, which brought out many features which should be of great importance to the contractor in their economic bearing on handling equipment and tools. First picture showed a piece of road construction in New York State under contract. The fault pointed out in this was that of double handling of material. Another point is that of using square pointed shovels which for that work were more inconvenient and expensive, and it is also pointed out that the shovels were too small.

It is readily appreciated that there is a certain speed per minute in which a man usually handles a shovel. With an ordinary shovel throwing into the cart at the height of his shoulder a man will throw about one shovel in about seven seconds. With a shovel the size of a teaspoon he would probably not throw more than 30 a minute and if it were the size of a coal shovel his work would be very slow, perhaps four shovels full a minute, more or less. There is a certain point at which the size of the shovel, as it is increased, will equalize the speed of his throw as the speed is decreased, and there is one point at which a certain weight of material on the shovel and a certain average of speed that corresponds to that weight will be economic. If the contractor uses the size of shovel different from that economic one it will cost more money to handle the earth than it need cost him, and the finding of that economic size is one of the problems of engineering as applied to this kind of construction. It is one of the problems that the contractor very rarely has an opportunity to investigate himself on the work which is of such magnitude as that illustrated. Mr. Taylor says that for work of about the same character as is shown in this picture the economic weight is a little over 20 pounds and for the average shovel work that is not far from accurate. The shovel shown lying on the ground is about the right size for mixing concrete on a board but it is only about half big enough for the purpose for which they are using it. They are short handled shovels instead of long handled shovels as they should be.

A point developed from this was that some of the members present stated that they never used short handled shovels but that many men could be found who are working with them, particularly railroad men. The statements that follow show that long handled shovels were the most economic in nearly every case and that the men like them better and will do better work after they have tried them, the short handled shovels usually being looked upon as a lazy man's tool. The theory of the use of a long handled shovel, especially if the man is throwing to any great height, is that he has no reason to lower his body or to raise up. It takes a certain amount of energy to raise and lower his body, which is a very large proportion of the work. The body above the hips of the average man weighs perhaps 80 to 90 pounds, which is four or five times the weight of the material on the economic shovel.

It was also developed that the quality of steel makes a difference. An instance was cited of a job where Swedes were working on station work, that is loading cars for which they received so much per cubic yard. The contractor paid

Fig. 2.—Time Wasted in Handling Boulder for Lack of Chains.

50 per cent. more for the best quality of shovel than he would have paid for a poor one. Shovels made of good steel were found excellent to dig with and the earth slipped off more easily. The men seemed to do 10 per cent. more work in a day with a high grade shovel than they could do with a shovel of poor quality. The high grade steel shovel also weighs a few ounces less than a cheaper one. Even a few ounces overweight, when you throw every seven seconds, which is nearly nine times a minute or 540 times an hour, means a considerable number of throws in a day's work and represents much energy wasted. Then the men using the long handled shovel can throw five hours to the others two. He will never get a pain in his back and can keep it perfectly strong whereas if he uses a short handled shovel he would have to bend down so often that he soon becomes tired. These facts about long handled shovels are more appreciated west of the Mississippi and more are sold in that territory. The long handled ones, but so many more yards more than the short handled ones, but so many more yards can be thrown with them that the difference in the price is not appreciable. A contractor appreciates the importance of saving a few ounces in the weight of his shovel.

Another important point on the shovel question is the question of scientific data and the great importance to contractors of co-operation in the collection of such data. Even in such a comparatively small matter as shovels, study of economical design and practice is of much value. It is the kind of information that is needed and it will do the contractors more good than anything else in the discussion of elementary things of this kind.

It stands to reason that the prevailing factor in shovel work is the density of the material handled, because given the same length of shovel handle and the same general character of material so far as pushing the shovel into it is concerned, the weight at the shovel end is the important factor. To keep that economic weight you must have different shovels for different materials. If you are shovelling blue clay you want a smaller shovel than when you are shovelling sand. A contractor will realize that when he goes to shovel sawdust or snow, yet he will take the same kind of shovel to shovel blue clay that he uses for sand, and it requires an argument with him to put in two, three or four different styles of shovels.

Another picture showed work that was at least as good as the average on contracts of this kind. The pictures are intended to call attention to the vast opportunities of improvement in ordinary work. The men were loading stone to be put on the wagons by means of wheelbarrows and the incline there was of such a steep grade that they were just able to push them up and top them. Some lugs were arranged on the runway so that they would catch the feet of the wheelbarrow and prevent their rolling back. It was just about the maximum of what the men could push. The particular reason why this work was insufficient is that they did not have a pile of stone on a chute. Moreover, if they had had a sheet-iron apron to shovel from they could have shovelled the material more economically. In the first place, to use a man's labor to push a wheelbarrow up an incline like that is not economical.

Fig. 3.—Inefficient Drilling Due to Clouds of Steam.

At this point Mr. Dana made a digression to call the attention to a feature of the wheelbarrow which is not generally recognized. In the ordinary wheelbarrow the load concentrated at a point half the distance from the axle to the handhold. If the wheelbarrow weighs 80 pounds and carries a load of 120 pounds the total will be 200 pounds and the man will have to carry 100 pounds on his hands. Therefore it would seem to be reasonable to put the load as far forward as possible, even to the point where the load is entirely over the wheel, which is the principle of the charging barrow.

The Chinaman makes the wheelbarrow in about the same way he made it 2,000 years ago, with a wheel about 5 feet in diameter and the load right over the wheel. With this barrow he gets along very well with two women on each side of the wheel. He will also readily handle two barrows of cement or he will carry one barrow of cement by tipping the barrow to one side.

There is one particular feature about this proposition and that occurs in going uphill. If the Chinaman has a load right over the wheel and attempts to go uphill he will have tremendous difficulty in getting anything to push against. Reaction under his wheel is in such direction that the wheelbarrow will push him downhill without giving him a chance to push against it except by a movement of the arm from his shoulder, which tires him in a very short time. The trick in going uphill is to put some weight on the handles near his end so that for hill work or similar work to that he needs to have the distances between the loads and the hands a very appreciable length.

The work shown in Fig. 1 is a case that was represented as requiring a provision for in the specifications. The work was some state work in which the specifications read that the contractor was to receive so much per cubic yard measured in place. There was over a foot of ice and five feet of earth when the picture was taken. In that steam shovel work 15 per cent. of the excavated material was ice that had to be loaded on cars and it disappeared when the weather grew warmer. It was not paid for, yet it was just as costly as if it had been paid for. It was not the contractor's fault that the ice was there. The contract term required them to go on working in the winter. Under the circumstances it does not seem fair that the contractor should do 15 per cent. more work than he is paid for.

In reference to Fig. 2, the discussion turned to the best way for handling a situation of this kind. The ordinary bucket swing in that work took an average of 25 seconds. When a boulder like that shown in the picture was encountered it took an average of two or three minutes to juggle the boulder out of the way onto the cars. A suggestion that was offered was to have a special kind of chain by means of which the boulder may be picked up without any undue loss of time by the bucket. With a well designed chain and the shovel crew working properly it would probably take a minute to hook onto that boulder; in other words there would be a loss of about a minute for every boulder of that size. Another suggestion in reference to this was that of just having an ordinary chain going underneath the bucket and the boulder that enabled the shovel to pick it up and drop it on the car, an operation that did not take the bucket man any longer than it would with an extra man because the bucket was dropped down and the rings of the chain thrown over the shovel.

The work shown in Fig. 3 furnishes an example of a peculiar difficulty that arises in the use of steam drills as compared with air drills. The question has often been asked, which is the more economical. Although in a great many cases they will work out the same, in this case the men often could not see their work through the condensing steam. Before the work was reorganized they had a manifold that leaked about as much steam as the drills used and very often the men had to stop drilling until the steam cleared away. The work itself was particularly uneconomical because the entire cut had been blasted before with a shipment of bad powder. The powder had exploded but it was of such poor quality that the rock was only partly broken and the drills would stick in the cracks. It may be amusing to tell that a friend of the contractor who is an expert in drills told the contractor that the kind of drill to use for that material was a bull-bit, because with a bull-bit the soft rock would be cut a good deal faster. It was found that the drill when in the hole worked about five per cent. of the time and the rest of the time was spent in sticking, while the drillmen whacked the bar with a wrench. Taking the hardness of the rock and the nature of the drill itself with a sharp bit such as a bull-bit, the steam would frequently drive it into the rock where it was not cracked far enough to embed the drill therein and hold it there, the lifting power of the steam underneath the head being very much less than the cutting pressure at the end of the down stroke. It was also found that a heavy drill, 3¼-inch, was so powerful that it would stick, whereas a lighter drill would not stick and gave very much greater penetration per minute. After taking this type of bit in the hole, water jets were put into it to wash the sludge out, so where it formerly took six minutes when working well to drill two feet the same amount could be drilled afterwards in two minutes without any trouble.

Another difficulty not susceptible of engineering and mathematical analysis is the question of drilling holes without error. As the rock changes in quality the depth of the hole must be changed as well as the character of the loading. The rule in this kind of work is to have the drill working as near as possible at the head of the shovel.

It was a rather remarkable fact that when the drilling was at a rate of 36 feet per day, the shovel was just able to keep up with the drills and the work was started when the shovel was down at the other end of the cut. The drilling was improved in efficiency so they could drill faster and the character of the drilling was also improved so that the steam shovel was held up less by blasting. The faster the drills went the faster the shovels were able to follow them. The increase in drill performance was equal to the increase of shovel performance. In the early stages of the work the weather was very cold and because of the fact that the rock had been blasted before a considerable amount of dirt and broken rock fell into each hole so that it became necessary to blow out the dirt of the hole with a steam jet and also on account of the nature of the rock. The pipe used for the jet, as well as the hose, was quite heavy and that entire gang was necessary to do that work, which made it very expensive.

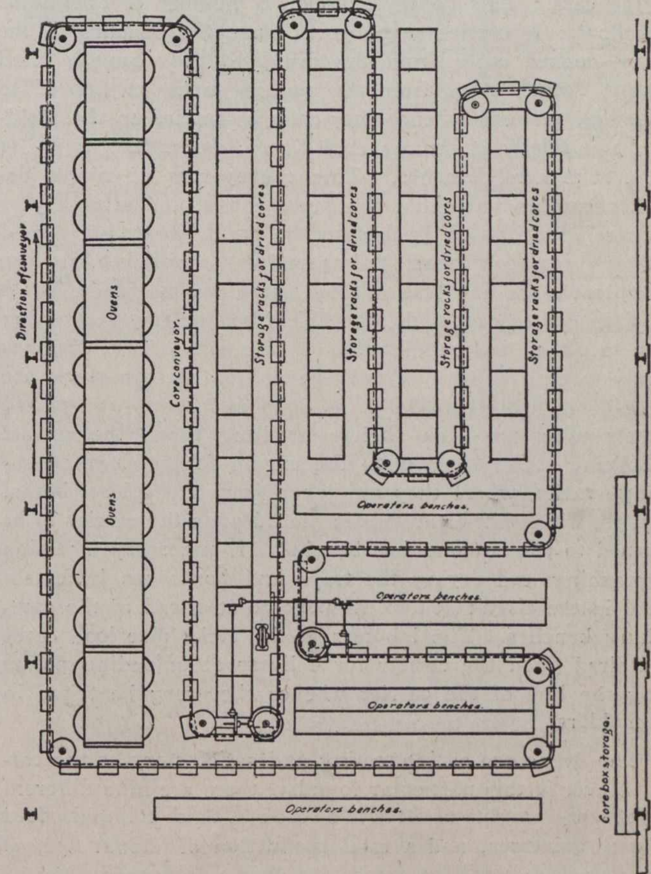
ECONOMIES IN CORE-MAKING.

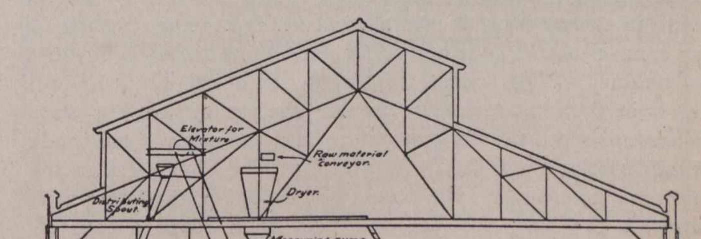
When the core-room of the average foundry costs, as it does, about a dollar and a quarter for non-productive labor, against every dollar that is directly productive, it is evident that some radical reorganization of means and methods is imperative. Such a change has been made in a certain foundry, and a large saving secured, by the use of properly adapted machinery, and an arrangement of work benches, and conveyors that ends the usual and wasteful walking to and fro of the workmen.

Various elementary labor-saving devices in connection with core-making have been adopted from time to time—such as power sand sifters, power mixers, multiple core boxes, mechanical squeezers or ramming machines, etc.; and some attempts have been made to save labor in handling cores to and from ovens and storage racks; continuous ovens have been devised. All of these measures have met with some success, though lacking in elasticity, as well as other essential features. But the increasing size of foundries has made it worth while for the engineer to study the problems offered.

A plant embodying many novel features, from plans by Mr. Hooper, of Hooper-Falkenau Engineering Company, industrial engineers, New York, has lately been put in operation, and has done its work with satisfactory speed and good economy.

The process begins with the raw sand brought by conveyor from the storage bin into which it has been dumped directly from the cars. This conveyor delivers the sand directly into a drier beneath which is a storage bin, which in turn, discharges directly into a batch-mixer beneath it. At the side of the batch-mixer are a measuring pump for oil and the water and oil valves, all operated by the laborer who handles the mixer. The mixer discharges into a belt elevator provided at its upper end with a swinging spout which discharges different mixtures into separate bins. From the bottom of these bins the various mixtures are dropped into





a barrow which runs on an elevated platform above the core-makers' benches. Above each bench and extending to within a few inches of it, is a galvanized chute open at the lower end. The mixed sand that is poured into this chute forms of itself a natural stop, the mixture flowing down as the pile at the bottom diminishes through use. So far there is little out of the ordinary save the use of the drier; although it may be noted here that two laborers handle easily all of the above work and could probably handle a tonnage half again as large with no over-exertion.

For the next stages of core-making, however, a number of unique features are in use, as will be seen from the accompanying cut.

Attention should first be given to the compactness of the general arrangement which puts the core-makers' benches close to the battery of ovens; while near to both benches and ovens is a set of cooling and storage racks.

Passing close to all of these in such manner as to serve them all is a conveyor consisting of cars of two shelves each, suspended at about bench height from an overhead rail, and pulled by means of a chain above and supported by the cars. This conveyor serves a number of operations as follows: It carries green cores from the benches to the ovens—cooked cores from the ovens to the cooling and storage racks; cores from the storage racks as desired to unloading stations whence they may be carried to the molders; and finally it returns core boxes, driers and trays, to the core-makers' benches. This conveyor is of simple design, consumes but about two horse-power, and after a year or more of operation is declared to break fewer green and cooked cores than hand transportation. Through its use the operative at any station does not leave his place. When the green cores are made, the drier, box or tray containing them is placed upon the carrier by the core-maker, who has merely to turn half-way around to do so. At the ovens the green cores are received by the oven attendants and placed directly upon the oven shelves awaiting them, the cooked core being then placed upon the carrier for carriage to the storage racks, where they are taken from the driers, boxes, or trays, which lattter are again placed upon the carrier to be returned to the core-making benches. If necessary a station for washing and drying the trays and boxes can be established in the circuit at a convenient point ahead of the core-making benches. The laborers at the racks also load cores as desired upon the carrier for delivery at unloading points along the line of the carrier whence they may be taken to the molders.

The ovens are as interesting and satisfactory as the carrier. Since, in this particular foundry, there are nine different shapes and weights of cores to be cooked, there being also four different mixtures, and a total production of about 30,000 cores per day, it will be recognized that a difference must be made in the cooking of the several kinds of cores; while at the same time the continuity of operation of the system must be retained. The ovens therefore, which are fired by oil, are built with independent circular shelves of varying sizes to accommodate the various cores; and the shelves are made of two sections separately by a baffle plate which closes the oven and forms the oven front. Thus one-half of the shelf is within the oven and half outside. Shelf room is thus always available for storing the green cores brought by the conveyor, this storing being in effect a new loading of the oven, since by revolving the shelf a half turn to withdraw the cooked cores, the half of the shelf that carries green cores is swung into the oven.

Here is, therefore, a continuous oven entirely devoid of machinery, requiring no skilled labor in operating, and capable of any desired variation or selection in its management. Ventilating apparatus is provided consisting of hoods over the fronts of the ovens connected with exhaust apparatus. This removes the very disagreeable fumes arising from the cooking of oil cores, and enables the oven chargers to work close to the ovens, as their duties require, without discomfort.

Service of over a year and a half has proved that this type of oven works thoroughly well in connection with such a continuous system, there being no lack of capacity or accommodation for the variety of cores brought to the ovens. This type of oven is not patented, it is said upon good authority that no patent can issue upon it. Every one is free, therefore, to make what use of it is possible.

It will be at once realized that the flexibility of this continuous system takes it out of the class of special apparatus and renders it available for any foundry having a sufficient tonnage. Size, shape, weight and mixture of cores are all readily and easily cared for by the conveyor and oven, while piece work rates for core-makers with day rates for oven tenders, storage-rack laborers and mixing and distributing laborers give rise to no conflicts. There is no time wasted in passing between benches, ovens and racks. The system is thus adapted as perfectly to the jobbing as to the specializing plant.

FRICTION LOSS IN NEW CAST-IRON PIPE.

A recent bulletin issued by the University of Illinois Experimental Station gives the following interesting information. Calculations for friction loss in pipes are at best somewhat uncertain, since the properties of flow are more or less indefinite. The roughness of the pipe, the workman-

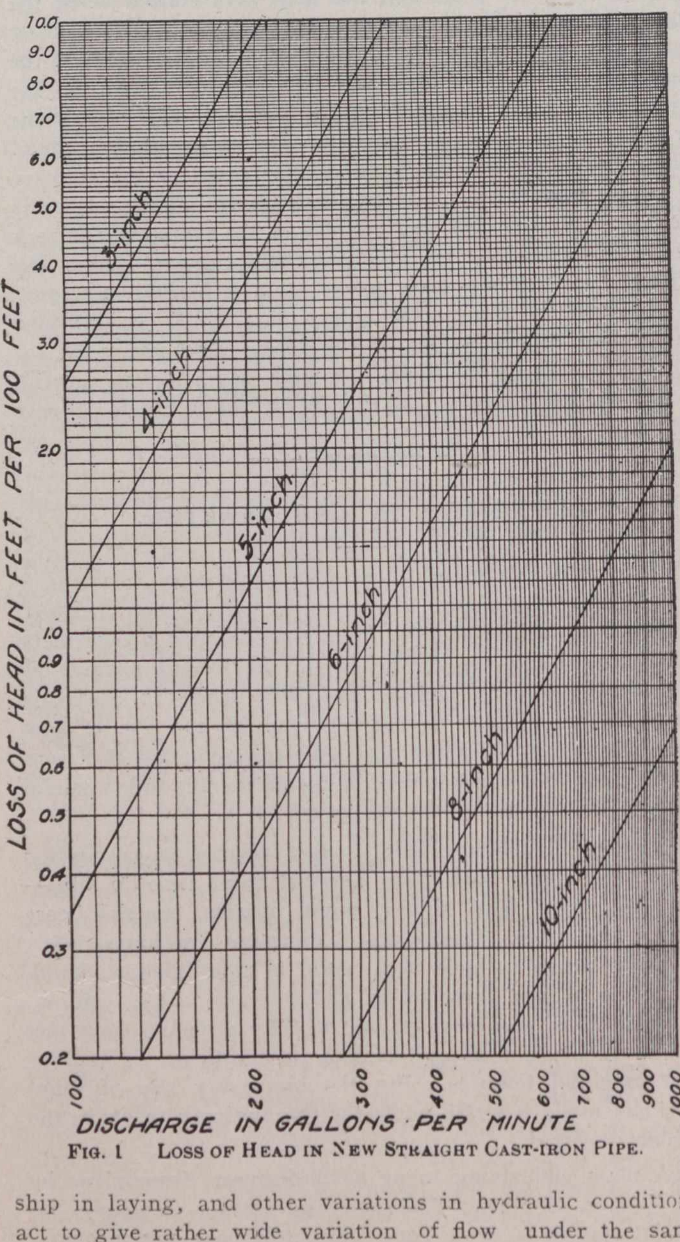


FIG. 1 LOSS OF HEAD IN NEW STRAIGHT CAST-IRON PIPE.

ship in laying, and other variations in hydraulic conditions act to give rather wide variation of flow under the same head. This is shown in the results of carefully made experiments which are accepted as standard work. Moreover, the difficulty of making experiments on pipe of medium and large diameters at high velocities has prevented the accumulation of as complete a set of data as could be wished. The best that can be done is to use the formulas and tables which most closely conform to well established data. Fortunately, it is generally not necessary to know the friction loss within close limits.

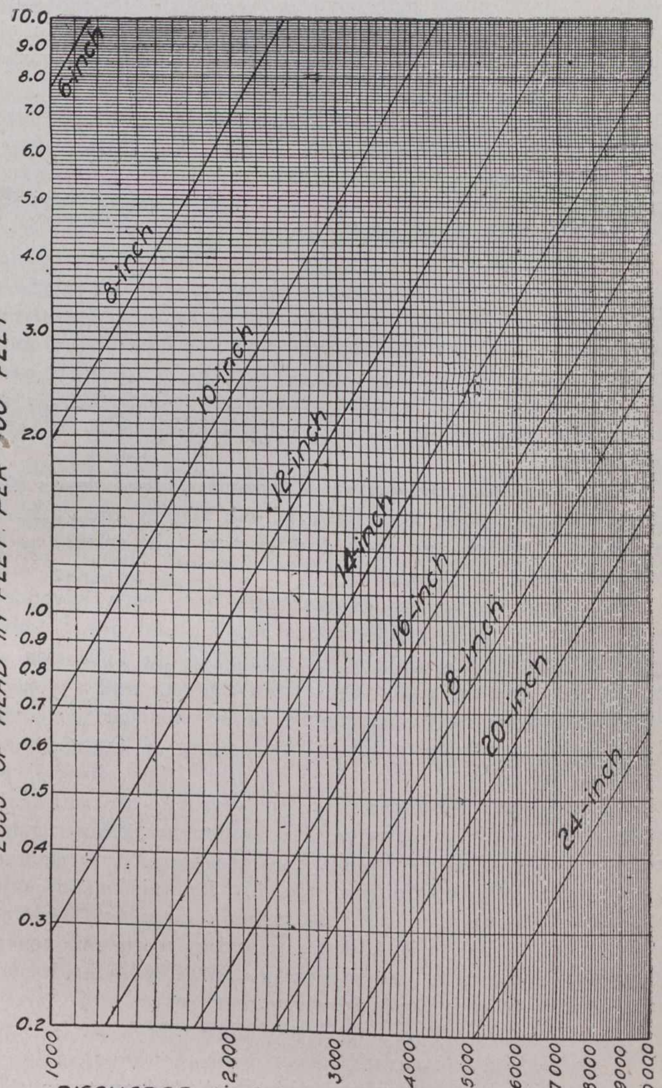


FIG. 2. LOSS OF HEAD IN NEW STRAIGHT CAST-IRON PIPE.

In Figs. 1 and 2, the loss of head in feet per 100 ft. of new straight cast-iron pipe for the discharge indicated by the abscissas has been plotted to logarithmic scale. Fig. 1 is for pipe having internal diameters from 3 in. to 10 in. and Fig. 2 for pipe having internal diameters from 8 in. to 24 in., though the extreme sizes in each diagram have little range of discharge. With a little practice, interpolation between lines may be made fairly accurately.

The diagrams (Fig. 1 and 2) are based upon the formula for pipe friction, $h = \frac{fl}{d}\frac{v^2}{2g}$, where h is the head lost in friction in l. ft. of pipe, d is the diameter in feet, and v is the velocity in feet per second; f is a factor depending upon the size and roughness of the pipe, and varying with the velocity of the water; g is the acceleration of gravity in feet per second per second. The values of the coefficient f used in preparing the diagrams are those given in Merriman's Treatise on Hydraulics. For the sizes above 6 in. the results are substantially the same as may be obtained from the formula: loss in 100ft. $= 0.044 \frac{v^{1.8}}{d^{1.25}}$. The results for pipe of sizes 8 to 24 in. agree very closely with those obtained from the tables of Williams and Hazen for a pipe after approximately three years of service and also with the results of the excellent diagram given in Turneaure and Russell's Public Water Supplies. They also agree with the formula of Unwin, a noted English authority. The values found by the tables and diagrams just referred to do not

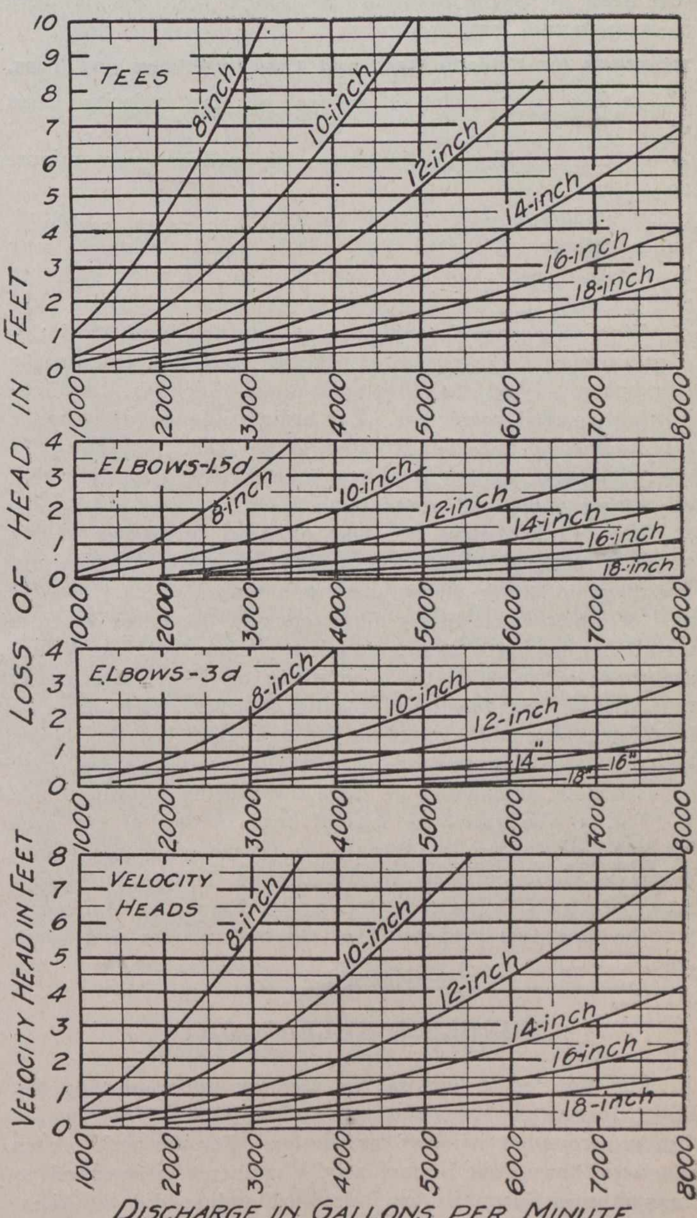


FIG. 3. DIAGRAMS FOR VELOCITY HEAD AND FOR LOSS OF HEAD IN ELBOWS AND TEES.

differ by more than about 5 per cent. from the values given by the diagram of Fig. 2 for the sizes named. It may be noted that this difference is much less than the variation in the results of experiments made at different times and places, and that a far greater difference may be expected with slight changes in the condition of roughness of the pipe. For sizes smaller than 8-in., the agreement of the several formulas is not so close. It is believed that the diagrams conform as closely to the results of experiments as any tables which have been published.

The values for head lost given by the diagrams for sizes from 8 to 24 inches diameter are generally smaller than those given by the Ellis and Howland tables and by the Darcy formula. A further difference is that these tables and formulas assume the head lost to vary as the square of the velocity, or nearly as the square, while the diagrams use 1.8 power. It seems that for high velocities, Ellis and Howland, and also Darcy, give a lost head which is higher than experiments show. The excellent form of the Ellis and Howland tables, and the convenience of Weston's tables, which are based on the Darcy formula, have made these two sets of tables favorites for general use. It must be borne in mind, however, that for sizes above 6 inches, the lost head given by them for the higher velocities, is more than the actual loss.

Diagrams for Velocity Head and Loss in Elbows and Tees.

In Fig. 3 are plotted values of the velocity head $\frac{v^2}{2g}$ corresponding to discharges in gallons per minute through pipes having internal diameters of 8, 10, 12, 14, 16, and 18 inches. Although the scale is small, the values may be obtained with sufficient accuracy for the uses given in this bulletin.

With an assumed coefficient of entrance head, 'm,' this diagram may also be used for finding the loss at entrance by merely multiplying the velocity head for the given discharge by the assumed coefficient. For ordinary forms of entrance this coefficient may be expected to be about 0.5, but it is not uncommon to use 1.0 for the coefficient, expecting that the larger value will cover other losses.

Fig. 3 also gives the loss of head in elbows of six sizes for given discharges in gallons per minute. The upper diagram is for elbows having a radius of curvature of axis of elbow equal to 1.5 diameters and the lower diagram for elbows having a radius equal to 3 diameters. The values are those selected by the Committee on Water Service as representing the maximum results of tests. Few data on large sizes and high velocities are available, but the values given in the diagrams are probably conservative and may be used until supplanted by more trustworthy information.

Fig. 3 also gives the loss of head in tees of six sizes for given discharges per minute, as presented by the Committee on Water Service. Information on the hydraulic properties of tees is even more incomplete than that of elbows, but the diagrams probably give the best results now available.

WIRELESS TELEGRAPHY.

For his recent lecture on wireless telegraphy at the Royal Institution, Mr. Marconi had erected in the lecture theatre a complete wireless installation. For the aerial, kites had been flown, but almost at the moment he intended to transmit messages, the wind dropped and so did the kites.

The burden of the lecture was an exposition of the astonishing anomalies connected with the distance of transmission, in which wireless work abounds. Some of these are not new acquaintances, but, old or new, they have this in common, that no adequate and satisfying explanation of them has yet been advanced. With moderate power stations on ships, the distance over which communication can be made during the day is generally about the same, and independent of the bearing of the ships to each other or to the land stations. But in the night curious results are obtained. Ships off the north of Spain, or the coast of Italy, can nearly always communicate with the Post-Office stations in Britain, but when the same ships are at a similar distance away, but in the Atlantic, on the usual track between England and America, they can only communicate with those shore stations by using specially powerful instruments. In the former case the Alps have to be traversed, yet in the latter case a night transmission of 1,000 miles is exceptional. Again, there is the well-known interference in daytime with the passage of short waves, while long waves are sometimes more effective in daytime than at night.

There is also the peculiar effect of direction of transmission upon the maximum distance of transmission at night. This is much more in a north—south direction than in an east—west. During night-time, mountains which obstruct the waves during the day entirely lose this characteristic.

There are in addition daily variations in the resistance offered to waves; variations so regular that they may be anticipated, and so dependable that one may set the clock by them. Mr. Marconi has plotted a pair of curves, one for a wave length of 5,000 metres and one for a wave length of 7,000 metres, each expressing for a day the strength of signal received over the Atlantic with a constant strength of transmission. The immense dips and peaks are respectively produced in each curve simultaneously. Although at noon the 7,000 metre wave had an advantage in strength over the 5,000 metre wave, on the occasion of peaks such as at 10.30 p.m., that of the shorter wave topped that of the longer one.

It appears that the period of weakest signal across the Atlantic occurs while it is light at one station and dark at the other. The change from darkness to light seems, as it were, to reflect the waves.

Of course, numerous explanations have been advanced to account for these phenomena. The interference of daylight with the waves has been attributed to the ionisation of the air by the ultra violet light from the sun and a consequent absorption of the electricity by the ionised particles. Mr. Marconi attributes much of the success of Trans-Atlantic signalling to the use of air condensers. They have little loss by dielectric hysteresis and, in addition, are self-healing in the case of breakdown. The best transmitting results are now being obtained by dividing the waves into groups instead of a long continuous stretch. By this means one can obtain a double tuning; the primary circuit to the frequency of the wave itself, and the secondary to the frequency of constituent portions of the groups. At Clifden he is using a battery of 6,000 cells in series, each of 40 amp. hours capacity. This is believed to be the highest voltage battery in the world, and it is gratifying to hear that no insulation troubles whatever have arisen with it. So adequate is the battery to the demands of the station that during 16 of the 24 hours there is no running machinery in the station beyond the rotating spark gap. The opinion that earthing is deleterious to good tuning is not held by Mr. Marconi; with his earthing arrangements he has never found the slightest difficulty. Moreover, there is something of a bogey about the anticipations of interference in high power trans-Atlantic work. During a recent Admiralty test at a receiving station eight miles from the powerful transmitter at Clifden, messages were received from Glace Bay without any interference from Clifden when the latter station was transmitting at full power with a wave length differing only by 25 per cent. from the wave radiated from Glace Bay. Arrangements are now approaching completion whereby radio-telegraphic communications between Canada and Ireland would be duplexed, giving simultaneous reception transmission.

Mr. Marconi interprets the results attained as showing that a large number of long distance stations situated in this country could be operated simultaneously, without mutual interference, by the use of slightly differing wave lengths. Between May 1, 1910, and April 30, 1911, 812,000 words were transmitted between Clifden and Glace Bay

The Canadian Engineer

ESTABLISHED 1893.

Issued Weekly in the Interests of the
CIVIL, MECHANICAL, STRUCTURAL, ELECTRICAL, MARINE AND MINING ENGINEER, THE SURVEYOR, THE MANUFACTURER, AND THE CONTRACTOR.

Editor.—E. A. James, B.A.Sc.
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Advertising Manager.—A. E. Jennings.

Present Terms of Subscription, payable in advance:

Canada and Great Britain:		United States and other Countries:	
One Year	**$3.00**	**One Year**	**$3.50**
Three Months	**1.25**	**Six Months**	**2.00**
Six Months	**1.75**	**Three Months**	**1.00**

Copies Antedating This Issue by More Than One Month, 25 Cents Each.
Copies Antedating This Issue by More Than Six Months, 50 Cents Each.
ADVERTISING RATES ON APPLICATION.

HEAD OFFICE: 62 Church Street, and Court Street, Toronto, Ont. Telephone, Main 7404 and 7405, branch exchange connecting all departments.
Montreal Office: B33, Board of Trade Building. T. C. Allum, Editorial Representative, Phone M. 1001.
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London Office: Grand Trunk Building, Cockspur Street, Trafalgar Square, T. R. Clougher, Business and Editorial Representative. Telephone 527 Central.
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Address all communications to the Company and not to individuals.
Everything affecting the editorial department should be directed to the Editor.
The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910.

NOTICE TO ADVERTISERS.

Changes of advertisement copy should reach the Head Office two weeks before the date of publication, except in cases where proofs are to be submitted, for which the necessary extra time should be allowed.

Printed at the Office of The Monetary Times Printing Company, Limited, Toronto, Canada.

Vol. 21. TORONTO, CANADA, July 13, 1911. No. 2.

CONTENTS OF THIS ISSUE.

COMPARATIVE CORROSION TESTS.

In view of the fact that manufacturers make a great point of the sulphuric acid corrosion test of steel, it is interesting to note that at a recent meeting of the American Society for Testing Materials one of the members gave a paper criticizing the value of such tests as a true indication of the power of a steel to resist corrosion. The following is an abstract taken from the above-referred-to paper and the discussion:—

According to the author of the paper on the subject, Cloyd M. Chapman, "a service test is the only certain method of demonstrating the true wearing qualities of the product, but a service test may require years to give the desired information," hence the demand for an accelerated test. He deprecated the sulphuric acid test as an unreliable indication of endurance in service, and cited two panels of iron and steel that had shown almost the same amount of pitting when exposed for eighteen months to the weather; while strips cut from the same plates showed a loss of iron of 6.7 per cent., and of steel of 83 per cent. when submerged for one hour in dilute sulphuric acid. He disclaimed any desire to be understood as claiming that the sulphuric acid test is useless, or that when properly used it may not give useful information, but he did wish to call attention to its utter inability to give a reliable indication of the relative ability of metals to withstand the corrosive action of the weather.

It was claimed by one member that the presence of copper in iron or steel had a very decided influence on the rate at which steel would go into an acid solution. Figures were presented in which the mere presence of copper seemed to drop the rate from more than 18 per cent. to about 0.43 per cent. As the analyses of the metals did not give the oxygen content, another member showed that while copper, as an alloy, might have a protective effect, as an impurity or mechanical mixture it might be the reverse of protective, and that the oxygen content was really the crucial point. He quoted case after case where the corrosion varied with the oxygen, and that, therefore, it was quite as necessary to know the oxygen content as the copper.

INSPECTORS AND INSPECTION.

Viewed from an engineering standpoint, the result of the enforcement of independent inspection of material or construction has been a better standard of work in general. Because of this, it might appear superfluous to ask what is the purpose of inspection. Specifications, when once drawn, should be lived up to. Obviously, inspection is enforced to see that this is carried out. This constitutes the theory. But what of practice? Does friction ever arise between those appointed to inspect work and the manufacturer or contractor, as the case may be? The answer to the last question provokes a smile—a broad one in many cases.

As to the causes of such friction, that where dishonesty on the part of the manufacturer or the contractor is involved must necessarily be set aside from this argument. Such cases bring their own reward. Nowadays, it is a fully recognized business principle that it pays to furnish the best quality, so that where friction arises when this is the purpose of a firm the causes are well worth looking into and considering.

In many instances, it seems to be the intention of inspectors to prove that they are "doing something" by continually finding fault in a manner which, if it were applied to themselves, would be exceedingly offensive. One of the worst states of mind for any man to get into is that of habitual suspicion. This trait very seldom indicates good judgment, and if there is one occupation that calls for continual cool and quiet judgment, it is that of an inspecting engineer.

Where material or work offered for inspection is found wanting in quality, it is well for an inspector to keep in mind that this work is not the result of the plans of those in authority, but of some of the hired labor, and in consequence, a word or two with those actually responsible will generally produce the desired results. In other words, a common sense, quiet talk generally brings its reward, not merely in the patching up of some defective work, but in what is more to the point, the establishing a common understanding between all concerned.

It is as much the duty of an inspector to establish good-will, which in all cases is more productive of good results, as it is to merely look over a certain quantity of work per day. Producers in general are as thankful for any influence that promotes perfection in their work as are any other class of men.

MODELS FOR PROJECTED IMPROVEMENTS.

It is often customary when offering a scheme of civic building for improvement to have some one draw up a colored drawing of the new building or area, as the case may be, and this is shown to those financially interested. Many of us can recall instances where the drawing gave very little idea of conditions as they finally turned out. This is more noticeable in the case of building, the reason being that the drawing seldom shows the surrounding features. In the majority of cases, the idea given is not complimentary to things as they would actually look.

In such cases as these, where large schemes are projected, why not have actual models built showing the building in place, the new scheme of roadways, trees, etc., and thereby give the persons untutored in imagining things a chance to see how objects will be actually co-related? The price of these models is not high; the return in time saved is large.

COAL ANALYSIS.

In one of our editorials in a recent issue, the value of buying certain commodities by analysis was pointed out. Not only should contracts be made on analysis basis, but the furnished article should be analyzed as a check. The following is an instance showing the necessity of such a procedure:—

The school board of a Massachusetts city has for some time been buying coal for the schoolhouses on specification, but only recently did it take any steps to see whether it was actually getting the quality it was paying for. Lately it has made the first analysis of coal delivered to it, and discovered that the coal was below the stipulated quality. As a result of this analysis, costing $10, the coal dealer has paid to the city a rebate of $873.01 on the payments for coal.

EDITORIAL COMMENT.

Mr. H. G. Tyrell has recently published a book, entitled "History of Bridge Engineering," the contents of which are extremely interesting not only from the mere historical standpoint, but also from the technical side.

* * * *

The National Bridge Company of Canada, which was organized in December last, and work then started on its new buildings near Dominion Park, Longue Pointe, Montreal, has made its first shipment of finished steel. Power was turned on a few days ago, and the shop machines put in operation, resulting in the first shipment for customers' contracts, within about forty-eight hours from the start. This is a new record in rapid construction for a large industrial plant in the Dominion.

LIFTING MAGNETS FOR FOUNDRIES.

At the Pittsburg meeting of the American Foundrymen's Association Mr. H. F. Stratton, of Cleveland, read an interesting paper on the application of lifting magnets for foundry service; in which its progress, so far, has been unimportant in this country. To prove the adaptability of the lifting magnet for this class of work, Mr. Stratton gave the following estimate of cost for a foundry melting 35 tons of metal daily, 300 days in the year. The cost of the magnet and crane installation, with a lifting capacity of 1,350 pounds of pig iron is $4,000. A crane and a magnet of this size can handle 35 tons per hour at an operating cost (wages, fuel, oil) of 48 cents (2s.) per hour, or 1.4 cents per ton. The annual depreciation on the $4,000 equipment at 12% would be $480, and as 35 tons handled twice per day for 300 days represent 21,000 tons handled annually the depreciation cost on this tonning basis is 2.3 cents per ton. This brings the total cost of handling, including wages, fuel, oil and depreciation, up to 3.7 cents per ton. The author was told by a gentleman well versed in foundry practice that 10 cents per ton is a fair figure to assume for the cost of loading or unloading pig by hand, and on this basis the saving would be $1,323 annually, or 33% on an investment of $4,000. To sum up, a foundry melting 35 tons of metal daily can instal both a crane and a magnet, and expect a return upon the investment, after allowing all charges, of more than 30%. If it happens that a foundry is already equipped with either an electric or locomotive crane a magnet can then be installed on a very profitable basis when the tonnage to be handled is considerably less. For instance, if an assumption be made that a foundry melts 20 tons daily, and that a magnet be installed on an existing crane, the cost of the magnet being about $900, then the cost of handling, per ton, including wages, fuel, oil and depreciation on the magnet, is about 2.3 cents, which would represent a saving in this foundry of about $924 each year, or more than 100% on the investment. "It is very earnestly hoped," said Mr. Stratton, "that these figures be not brushed aside with the assumption that they are theoretical and must be largely discounted. As a matter of fact, the costs of handling by a magnet are stated conservatively, and are being bettered in service daily." Handling scrap, in general, would be more expensive than handling pig iron, whether done by hand or by magnet, but the advantage in favour of the magnet is more marked in the case of scrap than in the case of pig.

A NEW METHOD OF WATER STERILIZATION.

Following many electrical demonstrations, discoveries have been made which unrolled before many investigators a field which had for its ultimation the nature of rays other than those commonly mentioned and placed under the heading of light. The more important members of this series might include those proceeding from a Crooke tube, the emanations from radium and its kindred elements, and the ultra-violet rays. The ultra-violet rays, though known of for some time have recently been employed in experiments which have been conducted to ascertain their powers of destroying organic life and growth in drinking water.

Bacteria in general, grow and thrive in a temperature of 10° C.—40° C. These may of course be rendered harmless by raising the temperature of the water in which they are residing to 100° C. (212° F.). This of course involves considerable trouble and expense and has been the incentive which has turned physicists and inventors into other channels seeking a means of sterilization other than raising the liquid to the boiling point. Conditions fatal to bacterial growths might be summed as shown:

Several times freezing and thawing.

Presence of oxygen (anaerobic).

Electricity arrests growth.

Sunlight is very destructive to bacteria; the sun's rays, however, must come in direct contact with the germs. The light from the electric arc has similar effects as sunlight.

Research showed the violet end of the spectrum to be the most active, and led on to a rich source of these ultra-violet rays being sought for.

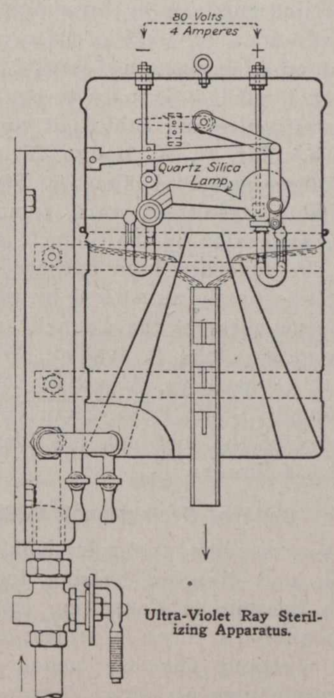
Ultra-violet rays were first produced on a large scale by Professor Finsen, using an electric arc between metallic electrodes, or the discharge from a condenser through a series of points. Professor Finsen used the rays only for therapeutic purposes, in the treatment of such maladies as cancer. The system was not developed commercially and it was not until the development of the mercury vapor lamp using a silica tube that sterilization of water by this means became a possibility. By the use of this lamp it became possible to generate an arc rich in ultra-violet rays, which readily passed through the silica tube but are almost completely absorbed by glass. In a paper read before the Association of Water Engineers of England Max de Recklinghausen described experiments conducted by him at Sorbonne University, in which water containing B. coli was sterilized by a 220-volt, three-ampere silica lamp, sterilization being obtained within one second at a distance of 10 centimeters, within 4 seconds at 20 centimeters, within 15 seconds at 40 centimeters and within 30 seconds at 60 centimeters. Temperature was found to have little effect upon the speed of sterilization, even including the freezing point.

Experiments with various classes of micro-organisms showed that they varied in their sensitiveness to the action of the rays. Destruction was found to take place in the following times at a uniform distance. Staphylococus, 5 to 10 seconds; cholera, 10 to 15; coli, 15 to 20; typhoid, 10 to 20; dysentery, 10 to 20; pneumonia, 20 to 30; subtilis, 30 to 60; tetanus, 20 to 60. Glass was found to be practically an absorbent of the ultra-violet rays and therefore must not be interposed between the rays and water.

From the above it would appear that water which is to be sterilized must remain within 20 centimeters (about 8 inches) of the lamp for at least 4 seconds, or within 4 inches of the lamp for at least one second, and that glass must not be interposed between the lamp and the water. This would apparently require either very low velocities or a great number of sources of ultra-violet rays placed within 2 or 3 inches of each other throughout the channel through which the water to be sterilized is to be passed.

Concerning the cost of this method compared with slow sand filtration which would cost about $10.40 per 1,000,000 gallons, the ultra-violet rays method would come to about $125 to $175 per 1,000,000 gallons.

A domestic sterilizer using this type of lamp, shown in Fig. 1, was imported recently by the Baltimore County Water & Electric Company for experimental purposes, and was installed at its office at Baltimore, Md. The water used for the test was city water just as received from the tap. This water often contains B. coli, and the number of bacteria per cubic centimeter is usually in the hundreds. The table given here shows the result of the tests made, and it is readily seen that the effluent in all the tests was practically



Ultra-Violet Ray Sterilizing Apparatus.

sterile. No change was made in the turbidity or color by the sterilizer. A 4-ampere current at 80 volts was used.

Results of tests:—

Bacteria Per C. C.									Raw.		Sterilized —B. Coli—			
Raw.	—Sterilized— 1	2	3	4	Average.	Per Cent. Removal.	No. Tests.	No. Positive.	No. Tests	No. Positive	Turbidity.	Color.
450	2	0	0	2	1.0	99.78	4	0	16	0	20	22
580	7	4	6	.	5.6	99.04	4	1	16	0	14	16
1390	5	2	0	4	2.7	99.81	4	2	16	0	15	14
310	8	4	2	0	3.5	98.88	4	3	16	0	12	10
490	4	6	6	2	4.5	99.09	4	2	16	0	18	12
210	0	0	4	2	1.5	99.29	4	0	16	0	20	12
600	0	0	0	1	0.2	99.97	4	1	16	0	16	10
720	4	2	0	3	2.2	99.63	4	2	16	0	15	8

From the American Waterworks Association.

The bacterial results from these few experiments are quite the same as the more extended tests carried out last July at Marseilles, France. The capacity of the apparatus in the French test was 158,500 gal. per 24 hours, and the process required 98.41 watt-hours per 1000 gal. The apparatus was attached to the outlet of a roughing filter, which was used simply to remove the turbidity from the river water. The water before being subjected to the rays from the lamp contained several hundred bacteria per cubic centimeter, and positive results were obtained for B. coli in all 1 c.c. samples tested. All of the samples from the effluent were practically sterile and B. coli. was entirely eliminated as well as pathogenic organisms with which the raw-water had been inoculated.

A PROFESSIONAL CODE AND SCHEDULE OF FEES FOR CONSULTING ENGINEERS.

The following code and schedule will be of interest to Engineers in general.

The American Institute of Consulting Engineers, a society formed a few years years ago in New York City for dealing with professional questions, has just completed two of its earliest undertakings by formulating a code of professional ethics and a schedule of charges for consulting, designing and other engineering service. A strong committee was appointed last January to deal with the subject of Professional Practice and Ethics; it consists of Mr. John F. Wallace (Ch.), Mr. H. W. Hodge, Mr. L. B. Stillwell, Mr. F. A. Molitor, and Prof. Geo. A. Swain. The present code represents the results of this committee's work with slight changes suggested by the Council and by members of the society. The code has been approved by vote of the members, and was finally authorized by the Council on June 23, 1911. The members of the Council are Gustav Lindenthal, Ralph Modeski, John F. Wallace, W. J. Wilgus, Rudolph Hering, C. O. Mailloux, Alfred P. Boller, J. E. Greiner and C. C. Schneider. Mr. E. W. Stern (103 Park Ave., New York), Secretary of the Institute, has furnished a copy of the code, which follows:

Code of Professional Ethics.

It shall be considered unprofessional and inconsistent with honorable and dignified bearing for any member of The American Institute of Consulting Engineers:

(1) To act for his client in professional matters otherwise than in a strictly fiduciary manner or to accept any other remuneration than his direct charges for services rendered his clients, except as provided in Clause 4.

(2) To accept any trade commissions, discounts, allowances, or any indirect profit or consideration in connection with any work which he is engaged to design or to superintend, or in connection with any professional business which may be entrusted to him.

(3) To neglect informing his clients of any business connections, interests or circumstances which may be deemed as influencing his judgment or the quality of his services to his clients.

(4) To receive, directly or indirectly, any royalty, gratuity or commission on any patented or protected article or process used in work upon which he is retained by his clients, unless and until receipt of such royalty, gratuity or commission has been authorized in writing by his clients.

(5) To offer commissions or otherwise improperly solicit professional work either directly or by an agent.

(6) To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects or business of a fellow engineer.

(7) To accept employment by a client while the claim for compensation or damages, or both, of a fellow engineer previously employed by the same client and whose employment has been terminated, remains unsatisfied or until such claim has been referred to arbitration or issue has been joined at law or unless the engineer previously employed has neglected to press his claim legally.

(8) To attempt to supplant a fellow engineer after definite steps have been taken towards his employment.

(9) To compete with a fellow engineer for employment on the basis of professional charges by reducing his usual charges and attempting to underbid after being informed of the charges named by his competitor.

(10) To accept any engagement to review the work of a fellow engineer for the same client, except with the knowledge or consent of such engineer or unless the connection of such engineer with the work has been terminated.

Schedule of Fees

As a general guide in determining fees for professional services, The American Institute of Consulting Engineers recognizes the propriety of charging: A per diem rate; a fixed sum; or a percentage on the cost of work; as follows:

PER DIEM RATE.—(1) Charges for consultations, reports and opinions should vary according to the character, magnitude and importance of the work or subject involved and according to the experience and reputation of the individual engineer, from $100 per day to a higher figure, and in addition where expert testimony is required or where otherwise conditions warrant so doing, a retainer varying from $250 to $1,000 and upwards. An additional charge should be made for all actual expenses such as travelling and general office expenses and field assistants and materials, with a suitable allowance for indeterminate items. In such cases six hours of actual work should be considered one day, irrespective of the actual hours of time devoted to the case.

Fixed Sum.—(2) A fixed total sum for above mentioned services may be agreed on in lieu of per diem charges. A fixed sum may also be charged for a portion or all of the items of preliminary surveys, studies, examinations, reports, detail plans, specifications and supervision, including all of the expenses above recited under per diem rate.

Percentages on the Cost of Work.—(3) For preliminary surveys, studies and report on original project, or for examination and report on project prepared by another engineer, including in both cases all expenses of every nature except those that may be specifically omitted by agreement—from 1½% to 3% on the estimated cost of the work.

(4) For the preliminary stage (3) and in addition thereto detail plans and specifications for construction, including all expenses of every nature except those that may be specifically omitted by agreement from 2½% to 5% on the estimated cost of the work.

(5) For the preliminary and middle stages (3) and (4) and in addition thereto general supervision during construction, including all expenses of every nature except those that may be specifically omitted by agreement—5%, but more for work costing comparatively small amounts, and from 4% to 5% where the amount involved is considerable.

(6) For full professional services (3), (4) and (5) and management, including the awarding of contracts, and including all expenses of every nature except those that may be specifically omitted by agreement, 10%; but more for work costing comparatively small amounts, and 6% to 10% where the amount involved is considerable.

(7) When desired, the percentage basis may be adopted for one or more stages, supplemented by a daily or monthly charge or fixed sum for the remaining stage or stages.

General Provisions.—(8) The period of time should be designated during which the agreed percentages and daily or monthly charges or fixed sum shall apply and beyond which period an additional charge shall be made.

(9) The percentages are to be computed on the entire cost of the completed work or upon the estimated cost, pending execution or completion.

(10) Payments shall be made to the engineer from time to time in proportion to the amount of work done.

(11) When alterations or additions are made to contracts, drawings or specifications, or when services are required in connection with negotiations, legal proceedings, failure of contractors, franchises or right-of-way, a charge based upon the time and trouble involved shall be made in addition to the percentage fee agreed upon.

RAILWAY TIES OF REINFORCED CONCRETE AND ASBESTOS.

A new reinforced concrete railway tie is being tested on the Bavarian railways, which seems to combine the elasticity of wood with the durability of steel and concrete. This tie uses asbestos fibres soaked in water and saturated with pure cement as one of the elements. The mixture after complete saturation with water forms a soft tenacious mass which does not permit tamping or ramming as concrete does, but reaches two-thirds of the breaking strength of concrete. After setting it can be drilled, nailed and hammered like wood and retains its hold upon other materials, better than wood. The concrete consists of 1 part cement, 1 part rubble and 2 parts gravel sand. The asbestos is used only below the actual seat of the rails. The ties are 2.7 m. (8.9 ft.) long, 22 cm. (8.8 in.) wide and 14.18 cm. (6-7 in.) thick. The cut shows the tie with the reinforcement of 8 mm. (0.3 in.) steel rods.

The seven steel rods of the tensile zone reinforcement are imbedded below the rail seat which is also of concrete and the asbestos is placed on top of this. This lessons the cost of the tie, as the asbestos is rather expensive. A tie costs $1.50 to $1.75. The weight is about three times that of the wooden tie, 220 kg. (484 lbs.) The setting of the cement and asbestos is much slower than that of concrete and is accompanied by formation of heat. Hydrates of lime are formed in the process, as asbestos (calcium-magnesium silicate) has only a little silicic acid due to impurities. The excess of lime in the cement (25%) is also changed to hydrate of lime with formation of heat. Whether the ties will meet the requirements of the expected wear and tear is still a matter of doubt, as they have only been used 5 months so far, although they have shown no defects within this time.—Zement and Beton.

CASEHARDENING.

As it is not always convenient to secure quantities of horns, hoofs, leather and other materials commonly used in casehardening a large number of articles, recent experiments have shown that articles made of wrought and low-carbon steel may be hardened sufficiently for ordinary purposes by packing them in a mixture of one part of saltpetre to five parts by weight of granulated charcoal.

NEW RADIUM FIELD.

A number of rich deposits of ores containing radium have been found in Australia. Near Mt. Poynter, in South Australia, is found uranophane, which contains 67 per cent. of uranium trioxide. In Western Australia has been found pilbarite with 27 per cent. of uranium.

MINING IN BRITISH COLUMBIA.

John Hendry.*

The year 1910, in the province of British Columbia, was a record year in mineral production, the total value of the mineral extracted being $26,183,505. It is interesting to note that the province has continued to maintain its average proportion of the mineral production of Canada. If the aggregate value of the production of the Dominion be taken for the 25 years from 1886 to 1910, at $1,120,000,000 (which allows about $95,000,000 for 1910) it would appear that British Columbia can claim to have produced between twenty-seven and twenty-eight per cent. of this large sum.

The aggregate value of the mineral production of this province for all years to 1910 inclusive is nearly $374,000,000. It is a striking fact, as indicating the substantial increase in the value of the mineral production of the province in recent years compared with those prior to 1906, that fully forty per cent. of this large value is the production of the last five years, while more than half (about fifty-three per cent.) is that of the seven years from 1904 to 1910. In 1910, there appear to have been serious decreases in the production of lead, copper and zinc, but these were more than compensated for by the unprecedented increase in that of coal. Never before in the history of coal mining in the province has there been so large an increase made in a single year, the two nearest annual increases having been that of 350,000 long tons in 1891 over the production of 1890, and of 323,000 long tons in 1909 over that of 1908. Last year's increase in net production of coal over that of 1909 is, however, greater than that of the two largest increases previously on record added together, or 794,000 long tons in this one year as against 678,000 tons in those two years.

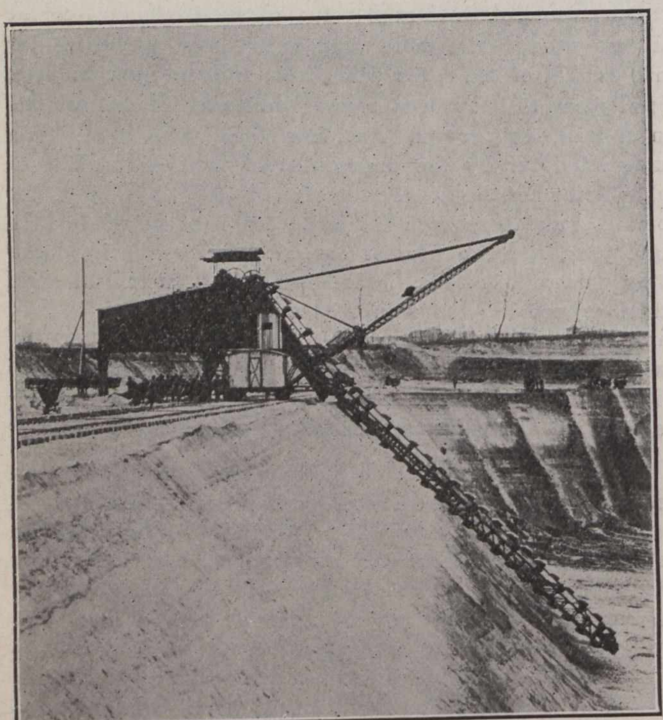
The expectations of those directly interested in the production of zinc, that there would be an increased output in 1910, were by no means realized; for the quantity marketed was small in comparison with the production of 1909. An unfortunate combination of circumstances brought about this decrease which was not the result of lack of ore. The burning of bridges and trestles along several miles of the Kaslo and Slocan railway last July took away from the mines their transportation facilities, so that continued shipment of mine products was quite impracticable during the remainder of the year. The destruction by fire of the Whitewater Concentrating Mill compelled a cessation of production there. It is hoped that the investigations which the Dominion Department of Mines is making in connection with the smelting of zinc ores, with a view to finding a solution of quantities of zinc and lead zinc ore known to occur in Koot-the problem of how to turn to profitable account the great enay mines, will be successful.

There was no production of iron ore reported in 1910 in British Columbia; nor, so far as known, has there been much activity in the direction of further development of known iron-ore properties. Some time ago the Dominion Department of Mines published a report by Mr. Lindeman on a number of iron ore deposits on Vancouver and Texada islands. The only additional information since received is concerning the discovery near Upper Campbell lake on Vancouver island, of a deposit of magnetic iron of high grade and purity, samples on analysis showing as high as 70 per cent. iron, .04 per cent. sulphur, .08 per cent. citarium, and .0087 per cent. phosphorus.

*Report of Commission of Conservation, Canada.

REMARKABLE EXCAVATOR FOR A HUNGARIAN CEMENT WORKS.

A very remarkable excavator has lately been installed in the clay pits of a cement works in Hungary, which is worthy of note, not only on account of its design, but also on account of its great capacity, as the guide alone has a length of 125 feet. The clay beds are composed of a comparatively light material—in layers of more or less sandy and moist, but not sticky clay—which lies in 16 clearly defined horizontal layers, the upper ones being richer than the lower. The material was formerly won and mixed by manual labor, but some years ago it was determined to substitute mechanical methods. In order to keep the works supplied with material of a uniform nature, it was, however, necessary to extract it from the beds—which have a thickness of 66 feet—in one single clean cut instead of working at different levels. This could naturally only be done by an excavator of unusual design and of very large dimensions.



A powerful engine works at a distance of about 1,315 feet from the engine house, on a track 920 feet long, and transfers the extracted material from two large drop chutes into a chain railway for conveyance to the mill. The cut of the excavator is in a straight line as the bucket chain can only be shifted parallel to itself if the material extracted is to be kept uniformly mixed. The bucket-chain, is, therefore, guided entirely in the excavator guide.

The frame of the excavator is designed in rolled sections and strong plates, and well stiffened by strong cross and diagonal bracings. The drive of the excavator is electromagnetic, the bucket chain being driven by an alternating current motor of 500 volts and 75 h.p. The movements of the bucket-chain, the travelling of the excavator and the raising and lowering of the bucket guides are quite independent of each other, and can, therefore, be actuated either simultaneously or successively. The movement is transferred to the bucket-chain by two drum sheaves provided with teeth.

A belt drive and toothed wheel drive are inserted between these sheaves and the driving motor. The belt is protected from the influence of the weather by plate casing, and, as is usual, the bucket guide is raised and lowered by means of a drum winch. Dredge buckets are employed for digging out and carrying the material, which are made in one piece from pressed steel plates having a bent shape and discharging to the rear. A knife is screwed on the blade side, which can be easily sharpened or exchanged. The material handled is transferred from the excavator shovels to the loading pockets, from which it is drawn off into chain railway cars.

On account of the unusual size of this remarkable excavator, a few details may prove of special interest. The working angle of the excavator guide is 47.5 degrees, the track is horizontal with a guage of about 10 feet. The distance from centre of the travelling track of the excavator to centre of the chain railway is nearly 14 feet. The projection of the counter-weight is about 50 feet and the counter-weight itself, which consists of paving stones, weighs 40 tons. The bucket guide, as already mentioned, has a length of 125 feet, with a dredger depth of about 65 feet. Pendulum feet are fitted on the rear side of the counter-weight, which come to rest when the excavator guide is relieved at any time, and in this manner carry the main part of the counter-weight.

This excavator, in spite of its unusual size, has proved most reliable and successful in working. The whole appliance was supplied by Adolph Bleichert and Company, London and Leipzig.

ELECTRICITY IN THE FOUNDRY.

Mr. Brent Wiley contributed a paper at the American Foundrymen's Association on electrical applications in the foundry, which contained much valuable material. He took the case of foundries with a capacity up to 2,000 tons per month, equipped with travelling cranes and electric drive throughout, the equipment being 220 d. c. The average conditions for these foundries would be: floor motors, one 75 h.p. air-compressor, one 20 h.p. cold saw, two 30 h.p. sand mills, eight 5 h.p. grinders, six machine-shop motors aggregating 50 h.p., one 25 h.p. repair shop motor, and six miscellaneous motors aggregating 58 h.p., a grand total of 323 h.p. In addition, there are crane motors, two of 50 tons each (280 h.p.), three of 25 tons each (250 h.p.), four of 10 tons each (180 h.p.), two of 5 tons each (90 h.p.), total, 800 h. p., and crane-hoist motors, total 400 h.p. A general rule for power-house capacities is that the average load will be approximately one-half of the total capacities of floor motors and crane hoist motors. In figuring the crane load on the power station it is to be noted that as the hoisting motion of the crane gives the heaviest load, and as it is seldom that more than one motion is used at a time, it is sufficient to consider the load on this motor only. As the crane work is very intermittent the load is very fluctuating, and the total capacity of power generators should not be less than twice the average load. As a general rule a spare generating unit will prove a paying investment to insure ample power at all times.

TITANIUM STEEL RAILS.

The New York Central Lines have ordered 41,500 tons of titanium Bessemer rails for 1911, specifying the use of 1 per cent. of the 10 per cent. ferro-titanium. This alloy is made according to the patents of Rossi, by the Titanium Alloy Manufacturing Company, of Niagara Falls. This order will, therefore, require more than 400 tons of the 10 per cent. alloy, which is believed to represent the largest single order ever placed for alloy steel rails.

THE STREET SURFACE.*

Geo. W. Tillson.

There is probably no one thing in the make up of a city that is of as much importance as its streets. This refers to their location and width, as well as their surface treatment.

As this article will deal principally with surfaces it will be taken for granted that the streets themselves have been properly located. Their surfaces, however, cannot be intelligently considered without giving some attention to width. But before taking this matter up in detail streets must be divided into three groups, namely, wholesale, retail and residential. It is understood, too, that it is often difficult to tell in advance to which group any street may belong and also if it will remain in that group permanently.

Streets have two functions, one to give light and air, and the other to facilitate travel, both pedestrian and vehicular. For the former purpose the width should be varied according to the height of adjacent buildings, and for the latter according to its traffic.

As a rule a wholesale street is not a thoroughfare, and consequently a width that will fill local requirements is ordinarily sufficient. For the same reason a wholesale street is used but little for pedestrians, so that a wide sidewalk is not necessary. A wide sidewalk is even a detriment, for, as in most cities goods are taken from the buildings across the walks to the trucks, these walks should be no wider than is absolutely necessary. If then the minimum width of a wholesale street is taken at 60 feet, how this width should be divided as to roadway and sidewalks is the question. In such a case as this it is easier to assume the vehicular than the pedestrian wants and if the former be satisfied without at the same time interfering with those of the latter, the entire solution ought to be fairly successful.

But one tier of trucks can be loaded in front of any building at one time. The large trucks in Manhattan, backed up against the curb, occupy 13½ ft. If the opposite side of the roadway be similarly used, 27 ft. in all will be blocked to transient travel on the street. As a general proposition the width of the roadway should be sufficient to allow trucks to load on both sides without impeding the lines of traffic each way. If the roadway be assumed at 40 ft., and 13½ ft. be occupied on each side, there would be left a width of 13 ft. in the centre, which will be hardly enough for this purpose. It is probable that both sides of the street will be occupied all the time, especially with the largest size trucks, so that traffic could move fairly well in both directions under these conditions; but if the sidewalk width should be reduced 1 ft. more on each side, making a roadway of 42 ft., there would be no serious obstruction to the traffic. This reasoning is based upon the idea that the entire street width is for the public and is not to be taken up by areas, stoops, railings or obstructions of any kind.

On retail business streets different conditions govern, as both the walks and pavement are used by many transient persons for a short time only and they are constantly coming and going, but as the vehicles deposit their passengers on the sidewalk it should, relatively in proportion to the roadway, be wider on a retail than on a wholesale street. Fifth avenue in New York is the greatest retail street in this country. It is 100 ft. wide and until recently has had a 40-ft. roadway, with sidewalk spaces 30 ft. wide. Areas and stoops, however, were permitted to a width of 15 ft., thus reducing the actual width available to the public to 70 ft. In 1909, between Twenty-fifth and Forty-eighth streets, the curbs were set back 7½ ft. on both sides and all encroachments removed to a distance of at least 2½ ft. from the building line, causing to be taken down stoops that had been in use for more than fifty years. The entire operation give a roadway 55 ft. wide, with an available sidewalk width of not less than 20 ft. This new roadway width permits three lines of travel on each side of the street without interference, and the sidewalk width is ample for present needs. The result here has been so satisfactory to every one that the same treatment will be continued as far north as Fifty-eighth street and also applied to many other of the wider streets and avenues where the traffic is congested.

This is of course an exceptional case and is given as an instance of what was considered the proper relation of sidewalks and roadways some years ago. Generally speaking, it would seem that the roadway should be proportionately less than as given above, for Fifth avenue is a thoroughfare and used by many who do not have business on the street. If an arbitrary rule were to be adopted, one making the carriage way one-half the width of the entire street would probably be satisfactory.

On residential streets the questions that have been discussed are determined more by sentimental than utilitarian principles. So much depends upon whether the street is or is not solidly built up and whether the buildings set back of or on the property line. The residential streets of Manhattan are 60 ft. wide, with roadways of 30 ft. This leaves sidewalk spaces of 15 ft., but as stoops are allowed to project 5 ft., the width available to the public is only 50 ft. The question immediately arises, if this width is sufficient, why should the city condemn and pay for a width of 60 ft. for public use? A width of 30 ft. is sufficient to allow the ordinary vehicle to turn around easily, and as a general proposition is sufficient for a residential street. On short and unimportant streets even this can be reduced without disadvantage.

When it comes to the selection of the material to be placed upon the street, much study is required. When it is known that city pavements have been in use for nearly six hundred years, and in this country for about three hundred, it would seem that the selection should be a simple matter. But it must also be understood that not one mile of the pavements considered standard to-day was in use or hardly thought of thirty-five years ago.

The first pavement laid in this country was in the old town of Pemaquid, Me. A few years ago a farmer at work in his field felt his plow strike some obstruction. He investigated the matter and discovered a street paved with cobble stones and curbed in the modern way. As nearly as can be ascertained, this pavement was laid about 1625, when Pemaquid was a flourishing settlement.

Boston laid its first pavement in 1650 and New York in 1656, both cities using cobble stone, it being the most available material at that time. And this same material remained practically standard until 1850, when Belgian blocks were introduced, the present oblong granite not being used until some twenty years later. Brick and asphalt were first laid in the 70's, and the present treated wood blocks some twelve or fifteen years ago. In the meantime, however, experiments were made with a great many kinds of materials, more or less successfully, till at the present time the standard paving materials are stone, brick, creosoted wood, sheet and block asphalt, and the so-called bitulithic.

In determining which one of these materials shall be used on any one particular street great care is necessary. The official should first know all the properties of the different pavements as well as the requirements of the street

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* Paper presented at the Third National Conference on City Planning, Philadelphia, Pa.

itself, as what would be very satisfactory under some conditions should not be tolerated under others.

The principal requirements of a perfect pavement are durability, smoothness and noiselessness. There are a number of other requirements, but time will not permit their discussion to-day. Now, while the pavements above mentioned contain all of these properties, no single one of them does, and it is in the selection of the one best adapted to any street under consideration that will tax the skill of the official to the utmost.

Granite is undoubtedly the most durable material and makes a pavement that requires few repairs. It is, however, noisy, and, as generally laid, rough and consequently not desirable for residence streets. It gives a good foothold for horses and will probably be most satisfactory for heavy traffic streets. The smoother pavements are, however, more slippery, so that granite must sometimes be used on account of steep grades on streets where naturally it would not be selected. The granite pavements of this country are much more objectionable than they might be on account of the roughness of the blocks themselves. To make a smooth block costs money, and for that reason blocks have been used that never should have been laid in any pavement. The remedy then is simple; make the blocks better, both as to shape and surfaces, so that they will not only lay closer, but present a much smoother surface when laid. The general practice with granite pavement has been to permit a ¾-inch joint between the blocks, filling the same with gravel, the interstices of which are also filled with coal tar pitch. By making the blocks of better shape and laying them stone to stone the joint can be kept so small that it will be practical to fill it entirely with pitch. This filler of pitch will materially reduce the noise of traffic, and, together with the smooth surface, give as quiet a pavement as it is possible to obtain with a hard, durable material. Some engineers prefer to fill the joints with cement grout. This practice unquestionably gives good results when properly carried out, but it means keeping the street closed to traffic until the grout is completely set. This is difficult to do in a street that is in constant use. Such a pavement as this is very hard to open and replace for subsurface work, and while, as a general proposition this might be a good thing in order to reduce openings to a minimum, it is often absolutely necessary to open a payment for repairs and new services, so that easiness of repair is an important factor.

During the last year or two, engineers have recognized the necessity for better blocks, and under present specifications a much better pavement has been obtained. It will require some time, however, to get the granite workers and pavers educated up to the required standard.

Brick can also be classed as a durable material and has been used with great success and in large quantities in the middle west. It is smoother than granite, and when good bricks are used makes a good pavement. Good brick cannot be made without good raw material, and many poor brick pavements have been laid because the bricks were made of poor clay and their character was not understood before being laid in the pavement. Notwithstanding the time brick has been used on streets, it was not until within the last year that a standard testing machine had been adopted. If this proves successful in separating the good bricks from the bad before using, poor brick pavements will be rarely found in the future. On account, however, of their weight and consequent heavy transportation charges, it is doubtful if they can successfully compete with other paving materials a great distance from their place of manufacture.

Since creosoted wood blocks were first used in Indianapolis, in the late 90's, they have come into use more generally than any other new material except asphalt. The principal reason is that a wood pavement is as nearly noiseless as it is probably possible to make any pavement. Its principal and almost its only objection is its slipperiness, and that occurs only when the pavement is wet or frosty. Just what its durability is cannot now be told. The first creo-resinate wood pavement was laid on Tremont street, Boston, in 1900. It is now in good condition and has cost almost nothing for repairs. Lower Broadway, in New York, has been paved with wood block for five years, and where it has not been disturbed shows practically no change from its original condition. Adjoining this wood, from Vesey street to Canal street, the previous granite pavement was renewed in twelve years. The durability of creosoted yellow pine blocks has surprised municipal engineers, and these blocks have now been accepted as a durable paving material.

Asphalt was the first material used for a smooth pavement, and its success has been phenomenal. It can be laid with an absolutely true and even surface, is easily repaired, and presents a pleasing appearance to the eye. It is more slippery than brick or stone, but less so than wood. It will, however, not stand heavy traffic, and it has received many set backs on account of its partial failure upon streets where it should never have been used. For residence or light business streets it is almost an ideal material, within grade limitations. Where the grade exceeds 4½ per cent. or 5 per cent., asphalt blocks can be used. These blocks are made of the same materials as the sheet asphalt, except the sand of the former has been replaced with crushed stone ranging in size from one-quarter of an inch downward. On account of the coarser mineral matter and the joints between the blocks, this form of asphalt pavement is less slippery than the sheet.

Bitulithic pavement is a bituminous product designed originally as an improved macadam, but gradually elaborated until it has become accepted as a standard pavement. It differs from sheet asphalt in that while the former is made up of sand, its particles being bound together by asphalt, the bitulithic is made up of broken stone in sizes from 1½ inches downward and so graduated as to present as few voids as possible, the pieces being held together with coal tar or in some cases with asphalt. On account of the size of the stones it is much less slippery than asphalt and has been successfully used on steep grades. It is a patented pavement and consequently has not been laid in as large quantities as it otherwise would, although it has been adopted very generally.

Knowing the properties of the different pavements to be used, the wants and needs of the different streets must next be considered. And the words "needs" and "wants" are used advisedly. The pavements are for both local and through travel, and these interests often conflict. The wants of people occupying the premises on the street also often differ altogether from those using them. For instance, the tenants of an office building wish a noiseless pavement and care little how often it wears out or how much work is necessary to keep it in repair. This call, however, must be heeded, as it is recognized at the present time that everything possible must be done to reduce the wear and tear upon human nerves in the modern city. Then, too, there are the needs of hospitals, churches and schools which must be located in many instances upon busy streets and whose work is seriously interfered with by noise.

In determining the needs of the different streets a complete knowledge of the amount and character of the traffic should be had, and it is probable that no city in the United States can furnish that information about its busy streets. The value of such information has been fully recognized in the borough of Manhattan, New York city, during the past year, where the necessity and amount of widening the roadways of certain streets have been determined by the result of the census of street traffic, both pedestrian and vehicular.

Another factor should be considered, the necessity of establishing through lines of vehicular traffic of all kinds. In all cities there are well defined lines of traffic, caused by certain conditions, such as topography of the city, location of docks, railroad stations, bridges, etc. In these times, too, attention must be given to the needs of the automobilists and provision made for them. Routes should be laid out for heavy traffic, where such are necessary, and independent lines for automobiles and light traffic, and pavements laid suitable therefor.

In the foregoing discussion no mention has been made of the cost of these different types of pavements, for as an abstract proposition that is not pertinent; but when it comes to a practical application it must be considered, as few cities have money enough for their pavement needs and must make the little they have go as far as possible.

Summing up, then, the principles herein laid down and applying them to general propositions, the author would say:

That for heavy traffic business streets a stone pavement will be most satisfactory, except where good brick is available and stone is not. If, however, for any reason noise is an objection and must be gotten rid of as much as possible, wood blocks should be used up to grades of 2 per cent., where recourse must again be had to stone, but laid as heretofore outlined so as to produce as little noise as possible.

On retail, light traffic or residential streets, wood, the bituminous pavements or brick will be satisfactory, according to grade requirements, the former two probably more so than the latter, as they are less noisy. In the east, wood is probably the most expensive material, with brick next, and sheet asphalt the cheapest, but prices vary with seasons, localities and local conditions.

The author believes that for these latter streets, cost not being considered, wood will give the best general satisfaction, with sheet asphalt second.

THE NEW BAKELITE DISCS.

There has probably been no invention brought out in years in the mechanical field which has attracted such world-wide interest as the material known as BAKELITE. Technical men everywhere are now more or less familiar with this indissoluble composition as used for various purposes, but all are not so familiar with it as used in one of its most important forms, namely, valve discs.

BAKELITE is a composition which is practically speaking, indestructible, except from friction. The highest pressure and highest temperature have no effect whatever upon it. Neither do moisture or chemicals of any kind soften it.

The importance of these qualities as applied to valve discs hardly needs comment. Valve-Leakage and frequent renewal has been considered more or less an inevitable evil. BAKELITE discs have, however, proved that valve trouble can be a thing of the past in any kind of service. Their extreme hardness and toughness reduces wear even from fiction to a minimum and they can, moreover, readily be reground and refaced. BAKELITE discs are handled in Canada by a Toronto firm, Plastics Limited, of 148 Van Horne Street.

LIGHTING A FACTORY LOCATION.

By E. R. Treverton.

Among all the reports on lighting installations that have appeared in the past months there are comparatively few that deal with the question of lighting the rougher locations such as machine shops, mills, factories and the like, due to the fact, no doubt, that very little work has been done along this line, or that those conducting the work have little time to report on it.

It is the object of this article to describe the manner in which a very dark machine shop was lighted, by a very simple but effective method, and one that has given entire satisfaction to all concerned.

The location in question is a typical inside factory one, there being an aisle 40 feet wide, situated between two other aisles of a slightly greater width, and separated from them only by the columns that carry the roof. Four hundred feet of this aisle is used for general machine work, mostly lathe work. The height of ceiling is 12 feet. The ceiling is formed by the floor above, of wood (2″ x 8″), and is divided into bays 40′ x 16′ by the supporting girders. A crane runs

the entire length of the aisle with a clearance of only 13″ above the hoist.

The natural lighting comes from the aisles on each side, one having a row of windows occupying the entire outside wall, the other making use of skylights and a row of windows just under the roof at a height of about 50 feet from the floor. The light from the first source was mostly cut off by a row of high machines directly in front of the windows and by the intervening columns, crane girders and the like. From the other side, the windows being so high in comparison with the width of the room, only a narrow strip of the floor was directly lighted, and this only imperfectly, on account of the machines located just along the edge of the aisle. It was necessary to use artificial light at all times, as under the best conditions of a bright day, the natural light was very dim, the mixture of daylight necessitating a higher artificial intensity than would otherwise have been necessary.

Formerly, clusters of carbon lamps scattered here and there, formed the general lighting scheme, each machine being furnished with one or more extension lamps which were moved from place to place as the operator required. Not only was the light insufficient, but the constant transfer of lamps with the consequent breakage and damage to the cord made the maintenance cost so high and reduced the efficiency of the workman, both in quality and quantity, to such an extent that some change was made necessary. It was impossible to keep good men on account of the inconvenience and unpleasantness of the location.

The small clearance over the crane, together with the low ceiling, excluded all types of lamps except the incandescent. Carbon lamps in sufficient numbers would have required an excessive current consumption so that Tungsten units were selected as being the most applicable. At the time there was some doubt as to the advisability of using Tungsten lamps as the floor above was used for machining heavy castings and the constant dropping of these, it was feared, would cause a large breakage of lamps, they being of the old fuse type.

In order to determine the exact effect that this would have on the life of the lamps, two bays were each equipped with a 100 watt, clear Tungsten lamps, with intensive glass reflectors, mounted directly on the ceiling, with one inch of free cord between the rosette and the socket. The lamps being in two rows, of four lamps each per bay, thus making the spacing distance 8' x 10', with a power consumption of 1.25 watts per square foot of floor space. The switching was arranged so that four lamps could be operated in a group thus permitting small areas to be lighted without waste. After several weeks operation the breakage was found to be only slight. With a replacement by the Westinghouse Wire-Type lamp the breakage has disappeared regardless of the vibration due to cranes and to the dropping of heavy weights on the floor above.

The illumination was uniform, and of sufficient intensity for the class of work done there, and the place was transformed from a gloomy into a cheerful location. The spirit of the men improved as was shown by the quality of the work turned out. The floor was kept cleaner and the whole appearance of the place improved. In fact, so satisfactory was the result that the entire 25 bays were similarly equipped. All extension lamps have been removed except where it is necessary to see into deep work, or under machines. For this purpose plug boxes have been placed at convenient places, and the extension lines are used only when necessary, with the result that the general lighting scheme is never interferred with, and the room is free from the mass of cord that generally characterizes like locations.

This system has been in service for well over a year, and careful records have shown that the cost is reasonable, and that the saving in quality of work, and the ability to keep good men has more than repaid the original expense.

The accompanying photograph, taken at night without any light except from the ordinary source, shows the location, and gives some idea of the satisfactory character of the illumination. All parts of the room are sufficiently lighted to permit of work being done with equal ease at any point. Tests showed that the average intensity on the horizontal plane averaged 2.5 foot-candles, with a minimum of 1.6 foot-candles at the extreme edge of the room.

THE EXPANSION OF CAST-IRON.

Cast iron, if repeatedly heated and cooled and kept free from the air, increases in size without any change in weight. In experiments with a bar 12 in. by 1 in. by 1 in. the heating and cooling being continued 35 times in succession, the bar grew to 12¾ ins. in length, the other measurements remaining unchanged. The chemical change increasing the length of the bar was owing to the conversion of the carbon to the graphite form. Wrought iron, soft steel and tool steel, similarly treated, showed a very slight contraction.

CHARACTERISTICS OF PERMISSIBLE EXPLOSIVES.

The following abstract of a paper by C. Hall, read before the West Virginia Coal Mining Institute, contains some very valuable information on explosives.

Tests of Explosives.—From September 2, 1908, to June 1, 1911, during which time the gallery for testing explosives had been in operation in Pittsburg, Pa., 143 explosives have been submitted for official tests, 84 of which have passed all test requirements of the Bureau of Mines and are considered permissible for use in coal mines under certain provisions The remainder have either failed to pass the test or have been withdrawn by the manufacturers when introducing new and improved explosives.

During the year 1909, 8,598,027 lbs. of permissible explosives were used in the United States. In the mines of Great Britain there were used, during the same year, 8,502,232 lbs. of permitted explosives. For the year 1910, the use of permissible explosives has shown a marked increase in the coal mines of the country. The returns received from the manufacturers indicate that the quantity used during the year 1910 will reach 12,000,000 lbs.

The underlying reasons why one explosive passes and another fails when tested in the presence of gas and dust have been investigated at the testing station. The results of researches made, especially on explosives which failed to pass tests, have been reported to the manufacturers and in nearly all cases resulted in the manufacturers so changing and perfecting their explosives that later when new explosives were submitted, they have successfully passed all requirements of the Bureau. The result of tests indicate that every explosive, if fired in very large quantities, will cause ignition of gas and coal-dust mixtures. An arbitrary charge; namely, 1½ lbs., has been established as the amount of explosive to be used in making tests and all explosives in order to be placed on the permissible list must pass the gas and dust test with this charge of explosive. A charge of 1½ lbs. per drill hole could never be exceeded in practice. In good mining practice it need not exceed 1 lb. and, accordingly, a greater factor of safety obtains.

Explosives of many different compositions are now on the permissible list, but all have formulated with a view to producing explosives which on detonation give a relatively low flame temperature of short duration. It has been found that in order to ignite inflammable gas and coal dust mixtures a certain temperature, acting through a certain length of time, is required. It has also been determined that the temperature, on detonation, of all explosives exceeds the ignition temperature of inflammable gas and dust mixtures, but fortunately the flame of the permissible explosives is of such short duration, when properly detonated, that the requisite time necessary for igniting the inflammable mixtures does not obtain.

It is evident that any factor that increases the duration of the flame temperature of a permissible explosive, such as the use of a weak detonator, or the use of any explosive not in accordance with the provisions prescribed by the Bureau of Mines, will increase the danger in their use.

The energy developed by the detonation of permissible explosives, like other high explosives, depends on the change of the small solid particles and liquids of the explosive into larger volumes of gases and the rate of detonation or the rapidity with which these gases are formed. To meet the varying coal-mining conditions in this country the manufacturers have formulated explosives varying in rate of detonation from 4,746 to 14,560 ft. (1,447 to 4,439 meters) per second.

It is evident that for certain work where a shattering effect is desired in driving through or bushing rock, or for producing coal for coking purposes, the explosive reaction should be rapid, and permissible explosives should be selected having a high rate of detonation. In a similar manner a suitable permissible explosive for use in soft friable coal and especially when lump or steam coal is desired, should be selected whic hdevelops its gases at a slow rate in order that the pressure developed will be more prolonged.

I have been informed that the coal operators of West Virginia are overwhelmed by agents of permissible-explosive makers with their various claims of efficiency. To establish their claims it means that their demonstrators must conduct a series of experiments over a considerable period of time in the mines. This procedure should not be discouraged, for the reason that the manufacturers are constantly improving their explosives and in many cases permissible explosives which are more suitable to the work have been selected as a result of such tests. However, much of this unnecessary work could be eliminated by careful consideration of the physical characteristics of each explosive before making tests. The chemical composition would be of little value to the operator and it is not proposed to publish such information. In several instances, in mining bituminous coal, it has been found that permissible explosives containing only 20 per cent. of nitroglycerin have given better results and produced better coal than those made under a similar formula containing 25 per cent. of nitroglycerin. The physical tests of explosives, such as in the United States Gallery of rate of detonation, strengths of explosives as determined by lead blocks, gages, ballistic pendulum, height and duration of flame, will be published as Bulletin No. 15 by the United States Bureau of Mines during the present month. This information will be of value to both the manufacturers and users of explosives.

Suppose, for instance, an operator has tried several permissible explosives in a certain mine where the coal is soft and friable and has selected one as the most suitable for the work in question. From this bulletin he will note that the rate of detonation of this explosive is 2,000 meters per second. Now suppose the operator receives a request to try out a new explosive. He should first ascertain the physical characteristics of the new explosive. If he learns that the new explosive has a rate of detonation of 4,000 meters per second it would be obvious that this explosive would be too quick in action and not suitable for this particular coal. It is true a powder man skilled in the use of a quick explosive might possibly in a limited series of tests, through special skill, demonstrate the new explosive to be more economical and at the same time equally efficient as a lower permissible explosive, but it should not be expected that the average miner would obtain the same results.

Use of Explosives.—By carefully considering the location of the drill holes and using special conditions in loading and tamping to reduce the pressure developed, a permissible explosive of a high rate of detonation could be successfully used in nearly all coal mines. It is well known that the pressure developed by the detonation of explosives in a closed space is directly proportional to the charging density; that is to say, a 1¾-in. drill hole loaded with 1½-in. cartridges will produce about half as much pressure per square inch on the walls of the drill holes as it would if loaded with cartridges of 1¾-in. diameter and, accordingly, explosives of a rapid rate of detonation if used in this manner would be productive of a better quality of coal. This procedure of air spacing to reduce the shattering effect is recommended by the Bureau of Mines.

There are other means of reducing the shattering effect of explosives, such as (1) the use of a weak detonator, (2) reducing the amount of stemming used in a drill hole, (3) using explosives that are frozen or partly frozen, (4) using cartridges of explosives of less diameter than were originally tested, (5) introducing foreign substances between cartridges of explosives, and other equally dangerous methods which not only eliminate the safety qualities of the explosives but enhances the chance of a resultant dust or gas explosion.

The American manufacturers deserve a great deal of credit for their efforts in producing suitable permissible explosives to meet the economic conditions in the coal mines of this country. Many of the permitted explosives used in European countries would not be suitable for use in the bituminous coal mines of this country for the reason that they are much stronger and quicker. If such explosives were used in mines of this country according to our American practice, depending to a great measure on the execution of the explosive, they would fail in their purpose. For this reason the American manufacturers have found it necessary to reduce the strength and quickness of explosives for coal mining purposes by adding inert materials or restraining substances. With explosives of this kind the average miner after a short time obtains successful and satisfactory results.

The ideal permissible explosive for use in shooting hard coal would be one that has a comparatively high rate of detonation containing all combustible materials and which on detonation produces the maximum volume of gases. Explosives of this kind could, no doubt, be used satisfactorily under all coal mining conditions, but, as stated before, they would have to be used in small quantities, in an intelligent manner, in coal previously mined so that the amount of explosive required would be that merely to exert a wedging effect on the coal.

This procedure is followed in many European countries and in some cases no explosives are used in friable coal or where the longwall system is used, but it is not expected that these conditions will obtain in this country for some time. Considering the comparatively high wages paid to miners in this country, cheaper coal can, no doubt, be produced with explosives rather than by pick work exclusively. But the excessive use of explosives, as practised in many of our mines to-day, is certainly unnecessary and is a menace to safety.

Nature of Permissible Explosives.—In order that the users of permissible explosives may know the nature and characteristic component of permissible explosives, I will take up the different kinds of explosives as classified in Miners' Circular 2.

Class 1. Ammonium Nitrate Explosives.—All explosives belong to this class in which the characteristic material is ammonium nitrate. This class may be sub-divided into two classes: (a) containing a sensitizer which is itself an explosive, and (b) containing a sensitizer which is not in itself an explosive. All the ammonium-nitrate explosives mentioned in this circular belong to sub-class "a" with the exceptions of "Kanite" A and "Masurite" M.L.F. These two explosives contain sensitizers which are not in themselves explosives and, accordingly, are classified under sub-class "b."

The ammonium-nitrate explosives of sub-class "a" consist principally of ammonium nitrate with small percentage of nitroglycerin, nitro-cellulose, or nitro-substitution compounds which are used as sensitizers. The explosives "Aetna coal powder" AA, "Bental coal powder" No. 2, "Bituminite Nos. 5 and 7, "Coalite" 3X, "Coal Special" No. 4, "Collier powders" Nos. 3, 5, 6, Special 5, L. F., and X., and "Monobel" Nos. 1, 2, and 3 are explosives of this class and contain nitroglycerin as a sensitizer. They are similar in composition to or a slightly modified form of the English permitted explosives "Abbcite" and "Monobel."

The explosives "Hecla" No. 2, "Titanite" 5, 7P, and 3P are explosives of the ammonium-nitrate class under sub-class "a" and contains nitro-substitution compounds as a sensitizer. These explosives, as well as those which will be mentioned later, under sub-class "b," have the advantage of not freezing when exposed to low temperatures for the reason that nitroglycerin is not used as an ingredient. They are a modified form of the English permitted explosives "Withnell" and "Favorsham."

The ammonium-nitrate explosives of sub-class "b"; namely "Kanite" A and "Masurite" M.L.F., consist principally of ammonium nitrate with small percentages of metallic oxides or other non-explosive compounds used as sensitizers. They are a slightly modified form of the English permitted explosive "Westfalite." They are detonated with difficulty, requiring an extra strong detonator and for this reason and the fact that they burn with great difficulty are one of the safest classes of explosives in respect to handling and transportation.

All of the ammonium-nitrate explosives are quite deliquescent, absorbing moisture from the atmosphere very readily. Great care should be exercised in storing them or using them in damp places. They are not suitable for use in wet mines. If an original package of an ammonium-nitrate explosive is opened in such mines and the cartridges are exposed for only a few hours to the damp atmosphere they will deteriorate, and many of the failures to completely detonate are attributed to this cause. The ammonium-nitrate explosives when stored under favorable conditions for only a few months show signs of deterioration, and nearly all explosives of this class, after six months' storage at the Pittsburg testing station, have failed to detonate or detonated incompletely when retested. For this reason the ammonium-nitrate explosives should be obtained in as fresh condition as possible and should be used as soon as possible after their receipt. The ammonium-nitrate explosives when in a fresh condition have the advantage of producing on detonation small quantities of poisonous and inflammable gases and are especially recommended for mines that are not annually wet and also in mines and working places that are not well ventilated.

Class 2. Hydrated Explosives.—All explosives in which salts containing water of crystallization are the characteristic materials and which modify the results of the explosion belong to this class. They are somewhat similar in composition to the ordinary low-grade dynamites, except that one or more salts containing water of crystallization are added to reduce the flame temperature. They are not now in general use and tests at the station and in the field indicate that the four hydrated explosives on the list at the present time are not as efficient as some other types of explosives. They have the advantages of being easily detonated, produce small quantities of poisonous gases, and can be used successfully in wet holes.

Class 3. Organic-Nitrate Explosives.—All explosives belong to this class in which the characteristic material is an organic nitrate other than nitroglycerin. The permissible explosives of this class are listed in Miners' Circular 2 as nitro-starch explosives. They do not contain nitroglycerin and for this reason do not freeze. They contain large quantities of inert matter and, therefore, are not as effective as they might be if they were made containing smaller quantities of this material.

Class 4. Nitroglycerin Explosives.—All explosives belong to this class in which the characteristic material is nitroglycerin. Of the explosives on the permissible list, 40 are classified as nitroglycerin explosives. The flame temperatures of this class of explosives are reduced by the addition of free water or by using an excess of carbon for the purpose of reducing the amount of carbon dioxide formed. A few contain salts which reduce the strength and shattering effect of the explosives on detonation. They are somewhat similar to, or a modified form of, the English permitted explosives "Britonite," "Carbonite," and "Kolax." The nitroglycerin class of explosives have the advantage of ease of detonation and not being readily effected by moisture. Less skill is required in their use and the average miner obtains satisfactory results with this class of explosives in a much shorter time than with the other explosives. They have the disadvantage of freezing at comparatively high temperatures and even when nitro-substitution compounds or other materials are added to lower the freezing point they will not remain unfrozen when the temperature falls below 35° F. They produce a large percentage of poisonous and inflammable gases on detonation, many of them producing quantities equal to that of black blasting powder. For this reason they should not be used in mines that do not have efficient ventilation.

Detonators and Fuse.—Permissible explosives are detonated by means of common electric detonators, the weights of fulminating charge varying according to the type of explosive used. When detonators are fitted with a means of firing them with an electric current, the device is called an electric detonator. As electric detonators are embedded in the explosives with which they are used and isolated by means of stemming, they are the safest means of igniting charges of explosives in gaseous mines. Common detonators are usually employed in connection with fuse. Fuse has therefore been called "safety" fuse and the practice still obtains, though the word "safety" has come to mean something far different than the original intention when associated with the word fuse. The variation in the moisture conditions of material to be blasted has forced the manufacturers of fuse to make several kinds in order that they will be adapted to the various conditions. There are five classes: (1) for the use in dry material; (2) for damp material; (3) for wet material; (4) for very wet material; (5) for submarine work.

The first two classes are generally used in the coal mines of this country. They are the cheapest grades and, on account of the lateral sparking which obtains on burning, are not recommended for use with permissible explosives. If the detonator is buried in the explosive, the lateral sparking which occurs with these types of fuse may set fire to the explosive about it before the detonator is set off. This has been the common cause of inferior and dangerous explosions.

Classes 3, 4 and 5 are well-made fuse and these grades show little, if any lateral sparking or glowing at the sides. However, even these classes of fuse are not considered permissible for use in gaseous mines. Tests made at the station, with fuse generally offered for sale in this country, have shown that the end spitting of the fuse will cause ignition of inflammable gas mixtures.

A new kind of fuse has recently been submitted at the station and the tests so far made indicate that it will be much safer than the fuse now generally used in coal mines. This fuse is of a good mechanical construction having a sufficient ratio between the pressure required to burst through the envelope of the fuse and the pressure produced within it by the burning powder train. The quantity of powder per foot is less than that which obtains in the ordinary fuse and in the preliminary tests which have been made at the station, no ignitions of inflammable gas mixtures have occurred from the spit of this fuse.

As fuse does not, per se, contain its own means of ignition, it cannot be considered apart from the fuse igniter, a means employed to cause the ignition of the fuse. Clearly, any fuse igniter that would ignite gas when properly attached to a fuse would be condemned as well as any fuse igniter which did not surely ignite fuse with which it is used. No great difficulty should be encountered when perfecting such a fuse igniter for there has been submitted to the Pittsburg station for test, a fuse igniter which, though it failed to pass the requirements, has some merit. It should not be concluded, however, that any fuse having the proper envelope and even when a safe and reliable method is provided for its ignition can be safely used in a body of inflammable gas.

There are various kinds of fuse sold of different rates of burning, varying from 18 seconds per ft. to 10 seconds per ft. when tested in the open air. The miner or shot firer seldom have the information of the rates of burning of the different kinds of fuse It is true that some fuse is marked slow or fast burning and it is also indicated by different colors of paper wrapper, but this is not always the case. Without such information a miner may become accustomed to a certain fuse and on using another brand of a faster rate of burning, the charge may explode prematurely. This is a menace to all connected with the work. It is generally conceded that the use of fuse of different rates of burning is not desirable, that if all classes were made to burn about 90 seconds per yard in the open air and this rate maintained within 10 per cent. over or under the stated time, such requirements would meet all ordinary mining conditions and offer greater assurance of safety. The manufacturers of fuse realize that the many kinds now manufactured having different rates of burning are unnecessary, and they would, no doubt, welcome a universal rate. It is believed that the required rate of burning of fuse; namely, 90 seconds per yard, recently adopted by the Isthmian Canal Commission and the United States Reclamation Service, would meet the various mining conditions in this country.

Tests have shown that the spit from squibs invariably ignites inflammable gas mixtures. As squibs must be propelled from the mouth of the drill hole to its heel by a propelling power of the spit of the squib proper, it seems quite impracticable to adequately protect this spit from inflammable gas mixtures within mines and hence the use of squibs of any kind cannot be recommended for use in mines generating inflammable gases.

The system of firing shots from the surface when all men are out of the mine by the use of electric detonators, previously adopted in Utah, has been introduced in Colorado, Alabama, and other states. This method has many advantages, and its adoption in mines where the local conditions permit would, no doubt, reduce accidents.

The dangerous practice of using inflammable material for stemming is generally being remedied by the employment of clay and like substances in all parts of the country. The humidifying of mine air by means of steam and water sprayers has progressed rapidly in the last two years. The enforcement of the law by the state mine inspectors concerning coal-mining operations has greatly improved in recent years. The mining conditions of this country as regards preventives of explosions are approaching a position of equality with European countries and it is expected that there will be a steady reduction of accidents from this source in the coal mines of this country in the future.

RELATION BETWEEN MODERN TRAFFIC AND THE ALIGNMENT AND PROFILE IN HIGHWAY DESIGN.*

During the past few years highway engineers have endeavored to find some method of road construction that will economically resist the excessive wear produced by a heavy automobile traffic, and at the same time eliminate the dust nuisance. Most of their endeavors have been confined either to incorporating a heavy bituminous binder with the road material, or to using a light binder or dust palliative on the surface, and although in a great many instances the results obtained have been successful, they have not always been economical. There is no doubt that some such form of construction is absolutely necessary for a road which is subjected to a heavy motor car traffic, and to use the one which will produce the result desired at the lowest cost is the most difficult part of the problem in the design of highways at the present day. Besides the particular method of construction, however, the relation between modern traffic and the alignment and profile of the road is a matter of great importance, and a careful consideration of this point will tend to produce roads that will not only be safer to the travelling public, but will also be more economical to maintain.

The design of roads suitable for a horse-drawn vehicle traffic alone will first be considered. According to theory the maximum grade allowable is the one over which the greatest loads expected can be hauled at the least expense. In practice, however, the maximum grade is also governed by other factors than the loads to be hauled, and in most states a maximum rate of grade is established which is never exceeded except when surrounding conditions and the consideration of cost make it advisable to use a steeper grade. Although the determination of the grade is affected somewhat by the surface drainage, the latter is of much greater importance when taken into consideration with the crown or transverse slope of the road.

It is customary in the design of ordinary roads to make the transverse slope from ½-in. to ¾-in. per foot sloping in a straight line both ways from the centre to the sides or else to secure about an equivalent amount of slope, by means of a parabolic or compound curve. On the steep grades a greater transverse slope is required than on the flat ones in order to guard against the danger of the water rushing down the grade and gullying out the road.

As far as the alignment of the road is concerned it is desirable of course to obtain the shortest distance between any two points, but in most instances the road to be improved has been laid out for many years, and to abandon it for any great length for the sake of shortening the distances would be of little benefit, since usually the cost is increased by the heavy grading encountered, and also whatever advantage there might be in having the old roadbed serve as a foundation for the new road would be lost. Therefore the old road is generally followed very closely; only the worst of its irregularities in line are straightened out and sometimes short detours are made in order to improve the grade. With horse-drawn traffic alone, neither sharp corners nor bad curves are considered detrimental to the road, as the speed of the vehicles is not great enough to make it dangerous or to cause excessive wear at these points.

In thickly settled communities where roads varying from 20 ft. to 40 ft. wide already exist, the full width is generally

* Paper by Henry B. Drowne, Assistant Engineer, States Board of Public Roads of Rhode Island, presented before the American Association of Science.

improved. On the trunk lines connecting towns with each other and with the cities a width of from 12 ft. to 16 ft. is found to be ample, and to give sufficient clearance between passing teams. The width chosen in any particular case depends upon the amount of money it is advisable to spend on the road, as the cost of the surfacing varies almost directly as the width, and only a heavy traffic would warrant the expenditure for a 16 ft. road.

In designing a road that takes either automobile traffic alone or a combination of automobile and horse-drawn vehicle traffic, the safety of the travelling public as well as the construction of an efficient surface must be considered. If the speed of the motor vehicle could be limited in the sparsely settled districts a large part of the road builders' troubles would cease, but although ordinances regulating the speed are in effect in almost every State in the Union, as a matter of fact they are disregarded about every time the opportunity occurs, with the result that the ordinarily constructed roads go to pieces.

Besides the danger of collision on roads subjected to automobile traffic where sharp curves occur, it is observed that at these points excessive wear takes place, particularly if the road is crowned both ways from the centre line. It is natural for all traffic to keep to the inside of the curve as closely as possible, and in the case of the motor vehicles, if the speed is not brought down to about 10 or 15 miles an hour, there is a slue to the hind wheels as they pass around the curve which tends to grind out the road material. The half of the road that slopes from the centre to the outside of the curve receives hardly any travel at all either from machines or horse-drawn vehicles, and the writer has observed this fact in several instances, particularly on very sharp curves. Conditions are the same on slight curves except the damage is much less extensive. In order to lessen the wear on the road and to protect the travelling public, it would seem fit that all curves should be eliminated or made as slight as possible consistent with economy. As long as one-half of the road, when it is crowned both ways from the centre, is not used, it would be best to make a one-way slope on the curve up from the inside edge and to increase the rate of this slope in proportion to the degree of curve. Practically the entire width of road is brought into use by doing this, and hence the wear is much more evenly distributed. As far as the alignment of the rest of the road is concerned, the straightest road is the best, as it gives a clear view, and therefore the tangents between curves should be as long as possible.

Perhaps a new location of the road would be of great advantage in some cases when both kinds of traffic have to be considered. Take, for instance, an old road with many sharp curves; it might be impossible to improve such a road by a new layout, so that many of the curves would be avoided and at the same time keep the new location near enough to the old so that the surrounding communities would be served just as satisfactorily. The advantage accruing from any such improvement would be a decreased cost of maintenance, a probable decrease in distance, a probable better grade, and a safer road to travel. The last item cannot be figured in dollars and cents, but its importance and worth should not be neglected in comparing the costs of construction between the old and new locations.

The crown of the road on the tangents should be as flat as the drainage of the road will allow, because the flatter the road the more evenly is the traffic distributed over it. The writer believes that a transverse slope of ½-in. to the foot, or its equivalent, is amply sufficient in any case, and that if the patrol system of maintenance is employed a slope of even less than ½-in. to the foot can be used.

The width out to out of the average touring car is about 6 ft., and a wider road is required than for the horse-drawn vehicle traffic, in order to allow the machines to pass each other at a fair rate of speed with the proper clearance, and still keep on the improved surface. Even on a 14 ft. road the writer has seen many places where the dirt shoulder has been displaced, so that the edge of the road metal is left exposed. This exposed edge is soon broken down by the action of the traffic, and sometimes the break is carried several inches into the road. On curves the same condition exists even to a larger extent, and the writer knows of places where the curve has been widened as much as 10 ft. on the inside, and still the traffic does not keep on the improved surface. Besides the damage done to the road on account of having too small a width there is also the grave danger of the machines being ditched, due to driving them on the dirt shoulder. In view of the foregoing, and in order to provide for the future, it would seem advisable to use different widths, depending upon the class of highway to be built. The writer will use the classification which has been recommended by Professor A. H. Blanchard, which is as follows: "The first class interstate trunk lines, interurban trunk lines, and popular routes of travel; the second includes interstate trunk lines passing through towns, the highways connecting towns situated within a few miles of each other; the third class includes feeders leading to towns and highways of the first and second classes from sparsely populated parts of the country districts, highways connecting towns which are many miles apart, cross roads and transverse feeders in towns." For the first and second classes a width of improved surface of 20 ft. would probably be none too great, while a width of 12 ft. to 16 ft. would be ample for those of the third class, the smaller width to be used in case of a very light traffic. On curves the road should be widened an amount depending upon the degree of curve and the inside edge should be protected by three or four rows of paving blocks or vitrified bricks laid on edge.

Fortunately the touring automobile is designed so that it is able to climb almost any grade encountered provided that the surface of the road is in good condition, hence the maximum allowable grade will be the same as for horse-drawn vehicles. It is observed that on steep rising grades there is serious deterioration near the foot of the hill probably due to the increased speed of the automobile in order to gain impetus, or to the changing of gears. Although a reduction in the rate of grade would help conditions, such a procedure would rarely ever be found to be either practical or economical.

There is little chance that the traction engine with its train load of 30 or 40 tons will ever become as common in this country as it is abroad. There has been, however, a rapid development in the past few years in the use of the motor truck which carries loads of from one to five tons. Present indications show that this type of vehicle is becoming more popular every day, and that before many years a greater part of the trucking of our large commercial houses will be accomplished by this method. Naturally this will affect the traffic on our highways, but there is no reason, as far as the writer can see, why the points already considered in regard to the relation of modern traffic with respect to the alignment and profile of the road will not fully cover the situation.

In concluding, some of the resolutions pertinent to this paper will be given which were adopted by the International Road Congress at the meetings held in 1908 and 1909:

To have moderate gradients with as small a difference as possible between the maximum and minimum, it being understood that in exceptional cases gradients may be sacrificed if necessary to avoid sharp curves.

To have the least camber compatible with the easy running off of rain water.

The radii of curves should be as great as possible, 164 ft. at least, the curves being connected with the tangents by parabolic arcs. The outside of the curves should be slightly raised, but so as not to inconvenience ordinary vehicles; no obstructions to the view should be allowed at the curves. A narrow sidewalk, bounded by a kerb, should be laid on the side of the shorter radius, and the depositing of heaps of materials should be forbidden.

The vehicles propelled by mechanical power cannot cause extraordinary damage to the curved portions of roads, provided that at these points a sufficient super-elevation is given, and that the curved portion is not approached or traversed at an unreasonable speed.

BOOK REVIEWS.

Good Engineering Literature, by Harwood Frost, Chicago Book Company, 226 So. La Salle Street, Chicago, size 5 x 7½, pages 420, price $1.00.

The author of this book was formerly editor of the Engineering Digest, of New York, and in this volume he has outlined the more important considerations in preparing articles for the technical press. The opening chapters deal with grammar, rhetoric and English composition; following that, the author takes up the matter of copy and publication.

The engineer is finding it not only more necessary but more pleasant to contribute to technical societies and periodicals and to edit his discussion before technical bodies.

The writer has had a wide experience in technical literature and has in this work produced a book that will prove of great value to every student, instructor, librarian, contractor, and engineer.

Notes on Irrigation Works, by N. F. Mackenzie, lately Under-Secretary for Irrigation to the Government of India; size 6 x 8¾, 107 pages, containing 11 illustrative drawings and six plates; price $1.80.

Under the auspices of the Common Fund of Oxford University a course of lectures on irrigation works was delivered by the author in the winter of 1909. The following were the subjects of the lectures: (1), Introductory, giving some general idea of irrigation works and their results. (2), The statistics required for the preparation of an irrigation project. (3), Types of weirs and the principles on which their design is based. (4), The development of Egyptian irrigation since 1884. (5), On the design of irrigation channels. (6), Irrigation revenue and land revenue in India. In short, this work is a presentation of these lectures in book form.

In the introductory pages of the book the author draws from experiences connected with irrigation as carried on in the past and in various parts of the world. The purpose and advantages of irrigation are discussed, and examples drawn from previous works undertaken in the past. In his chapter on statistics required for preparing an irrigation project, the author emphasizes the importance of this part of the work. His illustrations are drawn from the methods in practice in India at present. His discussion on types of weirs is of technical importance, and should be of interest in connection with this work. From a historical standpoint and indirectly from the demonstration of how the various methods of irrigation have been successful the chapter dealing with the development of irrigation in Egypt since 1884 is useful. A chapter upon the design of irrigation channels gives much interesting and valuable information, including an interesting comparison between previous practice in design and the best present methods.

The last chapter dealing with irrigation revenue and land revenue in India, while not directly pertaining to the structural features of irrigation, is nevertheless interesting, and from an economic standpoint is most fitting in a treatise on irrigation works.

Backbone of Perspective, by T. U. Taylor; size 4 x 6½, 56 pages; price $1.00. A book containing the theory of perspective and the explanation of its application to practical work. The discussion is arranged in three chapters, the headings of which are the Primary Methods, Vanishing Point Method, Axometric Projection and Shades and Shadows. The notes have been given in the form of lectures and drawing-board exercises by the author, but in this work they are reduced to neat attractive form, the mechanical arrangement of the work making very plain the topics under discussion. The subject of shadows is explained fully, many illustrative diagrams being given. In the book there are forty descriptive drawings.

Concrete Workers' Reference Books, by A. A. Houghton, 5 x 7, each containing about 60 pages. Published by the Norman W. Henley Publishing Company, New York City; price 50 cents each.

Four more of A. A. Houghton's reference books have recently been published. Each of these books contain some useful information about some special feature of concrete constructions, and are in handy form for use. Those in the series just published are:—

Practical Silo Construction, giving some valuable information relative to silo construction. Some of the subjects dealt with in the treatment are requirements of a silo, size of a silo, location, foundations for a silo, forms for silo construction, plastered silos, concrete block silos, kind of concrete and reinforcement to be used, doors and roofs for silos. The book contains 18 illustrative diagrams.

Molding Concrete Chimneys, Slate and Roof Tiles, treating with concrete chimneys and roof construction, shows many arguments for the use of concrete if used with discretion and honesty. Some of the topics discussed in this little books are requisites of chimney construction, small monolithic chimneys, inter-locking blocks for small and large concrete chimneys, forms for monolithic concrete chimneys, various types of concrete roofs, monolithic and reinforced slab roofs, concrete slate or tile roofs, molding hip ridge roll and gable ornaments, and preparing plans for roof loads. This book contains 15 descriptive diagrams.

Molding and Curing Ornamental Concrete gives many useful hints for the successful production of this growing field of concrete usage. Division of molds, coating of molds to prevent sticking, placing the concrete, repairing defects, surface treatment and curing of concrete, marble and granite imitations and molding concrete to imitate tool-dressed stone are some of the topics of this book. A rather thorough treatment of various types of molds concludes the book.

Concrete Monuments, Maasole and Burial Vaults, gives some pages to a discussion of another field of construction in which concrete seems to be steadily gaining in favor. For burial vaults concrete is said to be most desirable providing a strong and protective vault. Considerable space is given to the discussion of constructing concrete maasole. There are in this book eighteen descriptive diagrams.

The Design of Channels for Irrigation or Drainage, by R. Burton Buckley, C.S.I. 54 pages; 4¾ x 7¼; published by E. & F. N. Spon, Limited, London.

No better description of this book can be given than that appended to its title—"a statement of the various formulae in use and a guide to the practical application of them."

The writer goes very minutely into the practical application of the various formulae for calculating the flow of water in open channels. Special attention is given to Manning's formula, which the author claims is probably as accurate but not so troublesome as Kutter's formula.

The tables and diagrams given are very comprehensive, although it would have been an advantage if these diagrams had been printed on a slightly larger page.

A Handbook of Testing Materials.—C. A. M. Smith, M.Sc., Assoc. M. Inst. M.E. 284 pages, 6 x 9, fully illustrated, Constable & Co., Limited.

The stated chief object of the author is to interest engineers in experimental work. In the preface, it is pointed out that the descriptions of apparatus and tests have been made as detailed as possible, which is to be commended. Quite true, there may be many who, because of their experience, do not need such detail, but nothing is more discouraging to an enquiring reader than to find some small item left out of the description simply because a majority of readers are supposed to know it.

The various machines and the accompanying apparatus for carrying out the testing of materials are described fully in such a manner as to not only show their form but the principles involved in each. These descriptions are followed by numerous results of tests on materials, under which heading there is a very great deal of very useful information.

In the appendix, some very interesting results from the research on combined stress are given.

Taken as a whole, the book shows careful preparation and is admirably suited to bring about the author's object, for although there is a wealth of literature on this same subject, yet each new viewpoint, if carefully presented, is an asset to science.

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ENGINEER'S CLUB OF TORONTO.—96 King Street West. President, Killaly Gamble; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

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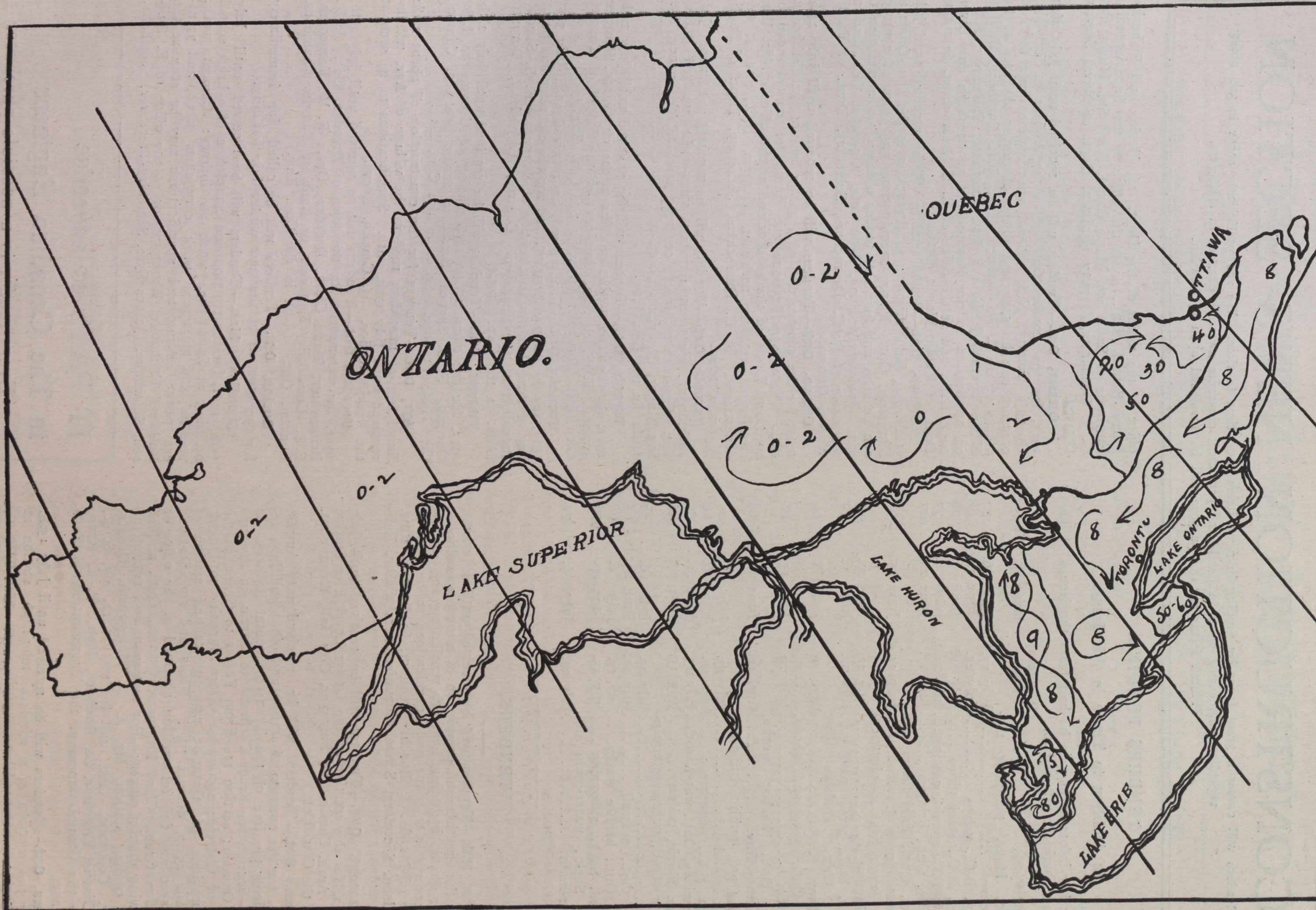
WESTERN CANADA RAILWAY CLUB.—President, Grant Hall; Secretary, W. H. Rosevear, 199 Chestnut Street, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg.



The normal chlorine conditions existing in drinking waters throughout Ontario are shown in the above map. In some localities shown salt pockets are found through the soil at various depths, even in districts where salt does not occur in sufficient quantities to mine. These districts, though not bounded by definite lines, may be seen to exist in the Niagara Peninsula, and in the north-eastern land between Toronto and Ottawa, nearer, of course, to the latter city. In the north land, where granite preponderates, it is a common occurrence to find salts of hydrochloric acid absent, or very low. Under ordinary conditions, fully allowing for all local circumstances, a water containing 12 to 13 parts of chlorine per million would be open to suspicion of contamination from sewage or other sources.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand and projected, contracts awarded, changes in staffs, etc. Printed forms for the purpose will be furnished upon application.

TENDERS PENDING.

In Addition to Those in this Issue.

Further information may be had from the issues of The Canadian Engineer referred to.

Place of Work.	Tenders Close.	Issue of.	Page.
Brandon, Man., pumping machinery	July 17.	July 6.	72
Burnaby, B.C., valves	July 24.	June 22.	68
Burnaby, B.C., steel pipes	July 24.	June 15.	66
Burnaby, B.C. special casting	July 24.	July 6.	72
Marshville, Ont., bridges	July 17.	June 29.	907
Montreal, Que., final filters and appurtenances	July 13.	June 15.	68
Moose Jaw, Sask., electrical equipment	July 24.	June 29.	908
Nanaimo, B.C., street paving	July 21.	July 6.	72
Ottawa, Ont., Hudson Bay Railway	Aug. 1.	June 8.	64
Ottawa, Ont., pier and sheds, Halifax	July 20.	June 15.	68
Ottawa, Ont., harbor works, Courtney Bay	Aug. 10.	June 22.	68
Ottawa, Ont., public building, Rock Island	July 17.	July 6.	29
Penticton, B.C., generators	Aug. 10.	July 6.	68
St. Catharines, Ont., water works.	July 13.	June 22.	66
Sault Ste. Marie, railway	July 15.	June 29.	64
Tavistock, Ont., pumping equipment	July 20.	July 6.	72
Toronto, Ont., seawall	July 17.	June 29.	68
Toronto, Ont., bridge works	July 17.	July 6.	68
Whitewood, Sask., sidewalks	July 15.	June 29.	908
Yorkton, Sask., water-main and sewer-main	July 24.	July 6.	72

TENDERS.

Halifax, N.S.—Tenders will be received until July 21st, 1911, for the erection and completion of a new schoolhouse on Tower Road, including heating, ventilating and electric wiring, according to plans and specifications to be seen at the office of Mr. W. J. Busch, Architect, 60 Bedford Row. R. J. Wilson, Secretary, School Commissioners' Office, Halifax, N.S.

Westmount, Que.—Tenders will be received until July 27th, 1911, for the erection of the Upper Level Fire Station (No. 2). Arch. Currie, City Surveyor, City Hall, Westmount. (Adv. in the Can. Eng.)

Ottawa, Ont.—Tenders will be received until August 3rd, 1911, for the erection of station and other buildings required along the line of the Transcontinental Railway, as follows:—Section 10—From Cochrane to Currie, in the province of Ontario; section 11—From Fraser to Grant, in the province of Ontario; section 12—From Superior to Dugal, in the province of Ontario; 1,000-ton coaling station at Grant, mile 232.7, district "D." Plans and specifications may be seen and full information obtained at the office of Mr. Gordon Grant, Chief Engineer, Ottawa, Ont., and at the following district offices:—For section 10 and 11 and the 1,000-ton coaling station, Mr. A. N. Molesworth, District Engineer, Cochrane, Ont., and for section 12, Mr. S. R. Poulin, District Engineer, St. Boniface, Man. P. E. Ryan, Secretary the Commissioners of the Transcontinental Railway, Ottawa.

Ottawa, Ont.—Tenders will be received until July 15th, 1911, for the erection of a wireless telegraph station at Sault Ste. Marie, Ont. Plans, specifications and form of contract can be seen at the office of the Superintendent of Wireless Telegraphs, Dept. of Naval Service, Ottawa; the office of the agent of the Dept. of Marine and Fisheries, Parry Sound, Ont., or at the office of the Superintending Engineer of Sault Ste. Marie Canal, Sault Ste. Marie, Ont. G. J. Desbarats, Deputy Minister, Dept. of Naval Service, Ottawa.

Ottawa, Ont.—Tenders will be received until July 26th, 1911, for the construction of a breakwater at Brooklyn, Queen's County, N.S. Plans, specifications and form of contract can be seen and forms of tender obtained at the offices of C. E. W. Dodwell, Esq., Dist. Engineer, Halifax, N.S.; Thomas J. Locke, Dist. Engineer, Shelburne, N.S.; on application to the Postmasters at Brooklyn and Liverpool, N.S., and at the office of R. C. Desrochers, Secretary Dept. of Public Works, Ottawa.

Ottawa, Ont.—Sealed tenders will be received until July 31st, 1911, for additions and alterations to the Post-Office at Kingston, Ont. Plans, specifications and form of contract can be seen and forms of tender obtained on application to Wm. Newlands & Sons, Architects, Kingston, Ont., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until July 24th, 1911, for the construction of a public building at Chilliwack, B.C. Plans, specifications and forms of contract can be seen and forms of tender obtained at the office of Mr. Wm. Henderson, resident architect, Victoria, B.C., and at this department. R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Toronto, Ont.—Tenders will be received until noon, July 18th, 1911, for manufacturing sixty-eight hundred (6,800) feet of 36-inch reinforced concrete pipe. F. S. Spence, Acting Mayor, Chairman Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until July 24th, 1911, for the construction of cribs at the city yards, Princess street. F. S. Spence, President of the Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until July 31st, 1911, for the supply of paint, and for the cleaning and painting of three bridges in the city of Toronto. F. S. Spence, President of the Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.).

Toronto, Ont.—Tenders will be received until July 24th, 1911, for the construction and placing of Groynes in Lake Ontario. F. S. Spence, President of the Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Ayr, Ont.—Tenders for the construction of about 2,282 lineal feet of macadam road in the village of Ayr, will be received until July 17th, 1911. Specifications to be seen at the Reeve's Office. H. Gmelin, Reeve.

Dresden, Ont.—Tenders will be received until July 26th, 1911, for waterworks for the town of Dresden, Ont. J. T. Bridgwater, Town Clerk, Dresden, Ont.; F. W. Farncomb, C.E., Consulting Engineer, 64 Bank of Toronto Chambers, London, Ont. (Adv. in the Can. Eng.)

Guelph, Ont.—Tenders will be called for immediately for the erection of the new winter fair building.

Snowflake, Man.—Tenders will be received until July 15th, 1911, for the erection and completion of a brick school building at Snowflake, work as follows: Cement work, masons' and plasterers' work, carpenters' work, and painters' work. Plans and specifications may be seen at the Builders' Exchange, Winnipeg, or at the office of E. Shilson, Snowflake. James Fyfe, Secretary-Treasurer, Snowflake.