When the surface of the scum was lifted more than 10 in. above the water line and there was danger of it overlapping the walls of the tank, the operator was instructed to break up the compacted sludge by means of a long-handled spade or rake and down through the scum, thus liberating the gases which were giving the mass its buoyancy. This was done partially every day.

Although the sludge when properly broken up settled back to the level of the liquid, within a few hours, it had returned to its original position and the process had to be repeated.

As this method involved considerable labor and had to be frequently repeated, another method of operation was adopted. In the open tanks it has been noticed that rain falling upon scum in an open tank tends to break it up and carry off part of the floating matter to the bottom of the tank.

The experiment was, therefore, tried of sprinkling the surface of the scum with settled sewage, no water being available at the plant. The water thus applied softened the crust which has formed on top of the scum, giving the mass of decomposition which has collected in the mass a chance to escape. Furthermore, it seems to increase the specific gravity of the floating matter sufficiently to cause it to separate from the water with the application of water a certain amount of stirring has been found to be of value.

At the point in the area of the sludge digestion chamber exposed to the atmosphere is approximately 28 per cent of the surface of the settling compartment. It is the opinion of the operator of the plant that the more serious the trouble from floating scum on account of the smaller surface from which the oil can escape.

**OPERATING RESULTS**

Table I gives the average analytical results of samples of sewage taken at the Moores-town sewage disposal plant, by the New Jersey State Board of Health.

Three separate determinations were made by the State Board, one on May 12, one on June 4, and one on July 10. Comparing the samples were taken on those days at half-hourly intervals covering the period from 11 a.m. to 9 p.m. Only one determination was made of the character of the raw sewage, namely on Sept. 10.

Considerable sedimentation takes place in the settling compartment, as is shown more than is indicated by Table I as the sewage on Sept. 10 was considerably weaker than that taken on the other two days. It appears that the grit chamber is entirely unnecessary, as the grit which has been abandoned when the old plant was remodeled. Its continued use entails considerable labor, not only in removing the large quantities of heavier suspended matter which settle out of the sewage, but in cleaning the grit chamber.

The plant yields an unusually clear effluent, free from sediment and very low in turbidity. The oxidation in the filters is very complete. This seems to be the efficient to be improved during the greater part of the time.

**Discharge of Inflammbale Wastes Into Sewers—Problem of Prevention—**

**The Pittsburgh Sewer Explosion Investigation.**

It is thought that some of the more recent and more violent explosions in sewers were caused by either, or both, volatile and gasogen vapor. If this belief is well founded it follows that the advent of motor driven vehicles has created a problem in sewer design and maintenance which it will be impossible to solve. Sewer systems are generally looked upon by the average person as quite an easy and easily maintained portion of the sewer matter which can be carried away by the sewer, without any consideration whatsoever of the effect of such discharge, either upon the structure itself, or upon its maintenance and operation. The transition in the mode of travel from horse-driven vehicles to the motor-driven car and auto-truck renders the transportation, handling and use of large quantities of gasole necessary and it is inevitable that in the handling of this material some will be spilled or wasted either by accident or design, which will find its way into the sewers. The solution of this problem is one of the attention of sewer engineers. The present article, which is taken from a paper by Mr. N. S. Latow, of the Department of Public Works, before the recent annual convention of the American Society of Municipal Engineers, discusses the discharge of inflammable wastes into sewer systems and the problem of prevention. The scope of the sewer explosion investigation now being conducted at the tests described. There are many sources which contribute inflammable wastes in a greater or less degree, ranging from the small and irregular discharges of gasolines, which may amount to considerable in the aggregate, to the large and intermittent discharges from manufacturing and storage plants and other enterprises which use large quantities of gasole.

In some cities (Pittsburgh included) the laws relating to the storage of gasole require that the tanks to be buried in the ground. These losses, which result from growth and evaporation, vary in capacity from about 50 to 15,000 gals. The purpose of placing them underground is to prevent possible ignition of the gas and protect them in case of fire. This is not the author's intention to discuss the advisability or the objection to placing gasolene storage tanks in the ground, but simply to point out the possible danger of gasolene escaping from these tanks and entering the sewers. The thickness of the steel plates of which the tanks are made, is generally from 1/4 to 3/16 in. and their only protection from corrosion is the application of ordinary structural paint. The tanks are placed directly upon the ground and因而 covered with earth. Under such conditions, corrosion is rapid. It is also possible, under certain conditions, that the tanks can suffer injury due to electrolytic action. In any case, there is no opportunity for inspection or repairs and leaks can only be detected by making a comparison of the quantity of gasolene put into the tank with the quantity removed. This information is in the possession of the owners and is not made available to the public authorities.

The possibility of gasolene escaping from the tanks into the ground and finding its way into the sewers may be remote, but with porous soil or a nearby catch basin or trap, the possibility for leakage into the sewers is at least present. In certain locations it is quite possible to set these tanks above ground, where ample opportunity for inspection and repairs would be possible. The gasolene from house-waste products is well distributed throughout the lateral sewer system and the average amount discharged at any one time so small that it is quickly dissipated before it can cause any serious damage. It is therefore to be supposed that the formation of explosive compound in large quantities of gasolene is not possible and that such explosions as have occurred in the past have been due to the magnitude of business and methods employed.

While the discharge of gasolene into the public sewers produces only that portion of any other inflammable waste, yet the discharge of gasolene products from paint works, oil refineries, gas works, etc., is likely to produce conditions, which, under favorable circumstances, may fill the sewer with explosive gas. Ignition of explosive gas, when present in the sewers may occur in various ways—for instance: Sparks from street railway tracks, hot cinders and spark from locomotive stacks, etc., ignites the gas in the manholes through the perforations in the covers, or when same are removed for inspection or repairs; also the dropping of matches or tobacco into the sewer, igniting a gas escaping; lights and sparks from tools, while making inspection or repairs within the sewer or at chambers, pumping stations or other plants.

The problem of preventing sewer explosions would then seem to be a question of either effectively sealing all openings into sewers or, exploding or regulating the discharge of inflammable or explosive wastes.

A number of cities have attempted to solve the problem by procuring legislation prohibiting or regulating the discharge of inflammable waste materials into the sewers. Prior to the general use of motor vehicles there were many industries and business establishments using inflammable and volatile wastes, such as dry cleaning establishments, paint manufactories, gas works, etc. Notwithstanding the fact that provisions have been made for ignition of gasolene vapor were uncommon. This fact would seem to indicate that the greatly increased use of the automobile industry has been responsible for many of the recent sewer explosions.

Accepting this theory as a working basis, we may deduce that the elimination of gasolene discharging into the sewers in large quantities by a relatively few people or in small quantities by a great number. In the first case the situation would be serious, whereas in the latter, it would be difficult. Moreover, it is necessary and important to determine whether the discharge of gasolene into the sewers is the primary cause of the explosions or whether the mechanical or electrical system was the cause of the explosions.

This scheme would not seem practicable. There is no practical way of providing sufficient ventilation means which would exhaust the air inside the sewer quickly enough to prevent the formation of an explosive compound in case large quantities of gasolene were present in the sewer. With the exclusion of large discharges of gasolene into the sewers, the danger of explosions can be greatly lessened by giving more attention to
the improvement of the natural ventilation. This would probably be sufficient to prevent the discharge of objectionable wastes. It would lower the normal amount of gasoline discharged into the sewers. To form an explosive mixture a certain amount of air and gas is required. If there is no air, or an excess of air, no explosion can occur.

It cannot be ignored that many sewer explosions are caused by the use of natural or artificial gas into the sewers. Evidence has been conclusive in a sufficient number of cases to show unmistakably that this is the fact. Proper regulation of the explosions from this source, however, is well within the jurisdiction of public officials; the remedy is the tight construction of the sewer system. The proper location of gas pipes. The remedy in this case consists, therefore, in the enforcement of powers that municipalities at present possess.

Modern sewer design provides for the ventilation and inspection of the structure. The discharge of inflammable wastes into sewer systems capable of itself be a serious matter, or objectionable, were it not for the possibilities of igniting the explosive compounds. Ignition of gases in the sewers could be prevented by the opening of such sewers. This would prevent inspection and create impossible working conditions inside the sewer when repairs were being made. Any of the sewers would not prevent ignition at chambers, pumping stations and disposal plants. In addition to the foregoing, there are other possible means for the controlling of the working of the sewers impracticable and inadvisable.

The exclusion of inflammable wastes from a sewer system brings up the question of how it shall be accomplished. The regulations of the Municipal Explosives Commission of the City of New York, adopted Jan. 3, 1915, require the installation of an "explosive preventer" and "ventilating apparatus." The city of Boston requires a special trap which will prevent the discharge of the objectionable wastes into the sewers, and the city of New York has emphasized regulations to those of New York, governing this matter.

The efficiency of these devices is dependent upon the attention paid to their operation by the individual. Careless operation or neglect might render them of little value and defeat the purpose for which they were installed. Therefore, frequent inspection should be made by the proper public officers. Their general operation is of no concern to the community. If gasoline or other inflammable waste is charged would seem prohibitive, if found advisable, on account of the cost. The compulsory operation of such devices will generally meet with opposition by those affected, which has been recently demonstrated by the case of the gas lines in the city of New York City repealing the ordinance requiring the installation of oil separators. I am informed that this repealing ordinance was vetoed by the Mayor.

Formulation of legislation directed toward the prohibition of the discharge of inflammable wastes is a matter of great attention in many cities. That same may be effectual requires the most careful consideration. It is most desirable that the necessity for such a prohibition be demonstrated and the efficiency of any devices thoroughly proven before they are required by ordinance.

The writer has examined the regulations of a number of cities and has come to the conclusion that it would be best from the standpoint of enforcement, to have all regulations of this kind in the same form, which would cover all phases of the discharge of wastes of all descriptions into the sewers. Such an ordinance should contain the follow-

(a) Prohibition against the discharge of any inflammable gas, volatile inflammable liquid, inflammable solids, liquids, or substances containing carbide or residue therefrom, or any liquid or other material or substance containing inflammable gas which would evolve an inflammable gas when in contact with water or sewage.

(b) Regulations as to how sewer connections with establishments from which the foregoing wastes emanate may be made. This may include the location of special traps, separators or similar devices.

(c) Provision for the examination and approval of all intercepting devices and provision for their inspection, maintenance and operation.

(d) Provision with regard to the discharge or placement of ventilating material in any part of the sewer system.

(e) Regulations as to the discharge of steam or hot liquid or gaseous waste into the sewers. The regulation of the discharge of gas pipes in the city streets with reference to the sewer; prohibiting the placing of gas pipes close to or within the limits of the sewer.

(g) Prohibiting connections from manholes, gate boxes, or other apparatus of public service corporations to the sewers, except in an approved manner and when properly trapped.

Legislation alone will not secure or prevent the discharge of these objectionable wastes into sewers. The people of the city are the first line of defense against the damage resulting from this practice, the offense will be greatly lessened.

It would appear desirable, in the interest of public safety, that where oil separators or similar devices are installed, for the municipality to undertake the final disposition of the residue retained in these separators. The importance of the problem of regulating the discharge of inflammable waste, etc., and the necessity of legislation to regulate has been amply and forcefully demonstrated by recent violent and destructive explosions.

As recent as Sept. 25, 1914, another serious explosion occurred on East 48th St., between 3rd Ave. and East River, New York, making the third explosion in the same sewer in three years. In all of these explosions the physical damage to the sewer, buildings and street, was not extensive. This is accounted for by the fact that the sewer was a brick lined sewer and the street surface well built. Under less favorable conditions of location and design this result would have been far more disastrous.

The most disastrous and expensive sewer explosion up to the present time, entailing no loss of life, occurred at Pittsburgh, on Nov. 30, 1913. This explosion to date has cost the city about $300,000, which may be increased by possible damage suits.

This problem is not confined to the prevention of genuine explosions in sewers, but may extend to all kinds of sewerage works as shown by the explosion in the screen chamber at the East of this year. In this explosion, which was caused by the presence of gasoline vapor, six lives were lost and three men severely injured.

The official statement of the Pittsburgh sewer board on these sewer explosions, it is evident from evidence covering many cities, that an immediate, effectual and permanent remedy must be found to control the situation. With three explosions in the 48th St. sewer in New York and two in the 58th St. sewer in Pittsburgh, all within less than a year, there can be no question but what the conditions inside of all large sewers draining garages, etc., are such as to cause frequent and serious electrical ignition occurs. The safety of the public and the welfare of the community are therefore now dependent more upon gas than upon the certainty of control, hence the public is always exposed to the hidden danger which only requires a chance spark to cause havoc and disaster.

The present situation can be likened to the man sitting on a leg of powder.

SEWER EXPLOSION INVESTIGATION AT PITTSBURGH.

The city of Pittsburgh, immediately after the severe explosion, sent an investigation and study with a view of preventing a repetition of such disasters. This investigation was made by the city engineers in cooperation with the local office of the U. S. Bureau of Mines, who have rendered valuable assistance and advice.

The purpose of this investigation, which is still in progress, follows: (1) To locate all possible sources from which gasoline or other explosive wastes might enter the sewers. (2) To determine by a series of examinations and tests the amount of gas or other waste discharged into the sewers. (3) To determine the presence, extent and quantity of vapor within the sewers. (4) Experiments to determine the effect of the fuel dumped into the sewer in different quantities and at different intervals.

The 58th St. drainage basin was selected for study because of the number of garages within the basin and the fact that two explosions have already occurred, indicating the discharge of large quantities of gasoline into the sewer. The 58th St. drainage basin has an area of 1,642 acres, a population of 53,765, and a total of 417 garages. In addition to gasoline and explosive materials are handled. These structures are classified as follows: 298 small garages, not more than two cars, includes private and small business garages; 67 large garages, not less than three cars, includes public garages, repair shops, large business garages, etc.; 12 gas from storage establishments; 1 dry cleaning establishment; 2 paint shops; 50 business or manufacturing places with fuel inflammable. The apparatus used is shown in the accompanying cut.

A map was prepared showing the outline of the basin, the sewer system within and the location of all garages, dry cleaning establishments, other inflammable objects or explosive wastes are likely to be discharged into the sewers. The map will be used in connection with studies to locate the points of contamination where the discharge of inflammable wastes occur.

Letters of inquiry were sent to all the principal cities in the country, objecting to data and information relative to sewer explosions and what laws or ordinances were in force regulating or controlling the discharge of explosives into the sewage of the sewerage systems. The answers received in reply to those inquiries were compiled and have been printed, and copies forwarded to each city supplying information.

Apparatus was designed for securing samples of air within the sewer and for making tests for explosive gases. The apparatus used is shown in the accompanying cut.

The results so far secured in the investigation indicate that large quantities of gasoline enter the sewers of both the 58th St. and Negley Run systems. This latter system drains an area of about 2,500 acres with a population of 25,000. It is believed some of the sources from which inflammable wastes are discharged than in the 58th St. system. Analysis of samples taken at this time at various points in these systems have shown that gasoline vapor in small amounts is present throughout the sewer system. The percentage of gasoline vapor detected varied from 0.065 per cent to 0.096 per cent of the volume of sewer air in the samples. While these percentages of gasoline vapor are considered too low to form a basis on which a possibility of discharge, above 0.1 per cent, can be taken as 92 per cent, it goes to show that the natural ventilation of these sewer systems is not sufficient to remove the effects of the ordinary or normal discharge of gasoline.

The Negley Run system drains through duplicate outlet sewers for a distance of over a mile, and there are no connections known which could by any possibility discharge gasoline. Above this point the sewers consist of a series of considerable length so that taking these larger sewers of the system together with the many miles of lateral, with the opportunity for natural ventilation would not suffice to remove the effects of the discharge of gasoline in large amounts.
Due expense upon the people, will secure to them freedom from the peril and danger to which they are now constantly exposed.

**The Milwaukee Sewerage Problem.**

To THE Editors: In your issue of Oct. 14, 1914, you printed a portion of a paper entitled "The Milwaukee Sewerage Problem," which I presented at the annual convention of the American Society of Municipal Improvements recently held at Boston. In this paper I stated that the Menominee Sewerage Commission, consisting of Messrs. John W. Alvord, George C. Whitley and Harrison P. Solly, had recommended that the preliminary treatment of sewage in Milwaukee should consist of chemical precipitation and disinfection. I made an error in this statement which I wish to correct. What this Commission recommended as a preliminary treatment for the sewage of Milwaukee, was grit chambers, screens and sedimentation tanks for the removal of suspended matters and a disinfection station—the effluent therefrom to be discharged into the Kinnikinic River. When this River could no longer provide dilution for sufficient oxidation, the effluent was to be carried through a 13 ft. tunnel under the bottom of Lake Michigan and dispersed on the bottom about 1,600 ft. from the shore. The Commission suggested that, in order to delay for some years the building of this large outfall tunnel, provision might be made for temporarily treating the sewage by chemical precipitation. It further suggested that Imhoff tanks might prove more advantageous than shallows, horizontal-flow well baffled tanks, and recommended a careful study of the conditions of these tanks to the conditions in Milwaukee.

In the event that sedimentation, disinfection and dispersion in the lake did not sufficiently dispose of the sewage, the Commission recommended that the tank effluent be further treated by sprinkling filters.

Very truly yours,

Milwaukee, Wis., Nov. 9, 1914.

**BRIDGES**

**Design and Construction of the Lower Ganges Bridge in India.**

(Staff Article.)

The Lower Ganges Bridge, which is under construction near Sara, India, about 115 miles northeast of Calcutta, will connect the 5-ft. 6-in.-gage system of the Eastern Bengal Railway south of the Ganges River with the railway north of the river. The bridge, which has a total length of about 5,600 ft., consists of fifteen through truss spans of 346 ft. 15 in. each, center to center of bearings, and symmetrical steel approaches, each of which consists of three 70-ft. deck girder spans.

The piers of the truss spans are spaced 258 ft. on centers, and their caisson foundations extend to a maximum depth of 100 ft. below low water level, the total height of these piers and their foundations being 252 ft. 6 in. The bridge has a clearance of 40 ft. at high water, the variation between high and low water levels being 51 ft.

A bridge at this site was proposed more than 20 years before its construction was sanctioned in 1908. Proposals put forward by the Eastern Bengal Ry. in 1889 were investigated by a committee and reported feasible. In 1902 Mr. F. J. Spring prepared a detailed project, and in 1907 a committee representing commercial interests recommended one of the "Sara" sites, which also had been favored by Mr. Spring. A technical committee appointed in 1908 reported that a bridge could be constructed and advocated a site near Sara. This was followed by the sanction of the Secretary of State to the construction of the bridge at or near Sara and the appointment of Mr. R. R. Gales as engineer-in-chief, at the close of 1908. Earlier proposals projected a single-track bridge with a clearance at high flood level of 30½ ft. and protection works on each bank. Further investigation and experience with the vagaries of the river resulted in the final design, for a double-track bridge with a clearance at high water of 40 ft., a public footway, and protection works at Raita and Sara in addition to more strongly built protection works at the site of the bridge.

**APPROACHES AND PROTECTION WORKS.**

The portion of the line which includes the bridge and its approaches is about 16 miles long. It starts just north of the Bhairamara station on the Eastern Bengal Ry. (see Fig. 1) and joins the northern section of that railway about three miles north of Gapayar. From the south (Calcutta) side the approach line to the bridge has a slope of 0.57 per cent for a distance of about 2½ miles. On the north (Siliguri) side the track is level for 2,000 ft. at Paksey station and then grades downward for about 3½ miles at a slope of 0.3 per cent. At the abutments the approach banks are 50 ft. high. Figure 2 shows a plan of the protection works at the bridge site and the manner of providing access to them.

Fig. 1. Site of Lower Ganges Bridge and River Bank Protection Works.

Fig. 2. Plans of Protection Works at North and South Ends of Lower Ganges Bridge—Note Approaches to Protection Works.

There are five roads under bridges through the high approach bank and two small culverts for local drainage. There are also four culverts beyond the northern approach grade for local drainage. These culverts are heavily protected against failure during floods. From the Bhairamara station on the south bank to the Ishurdi station on the north bank (see Fig. 1) the railway is double track; beyond these stations it is single track.

The problem of keeping the river to its course through the bridge was the most difficult one which confronted the engineers. The system adopted is that originated by the late Mr. J. R. Bell for rivers with erodible banks. At the bridge site there are two guide banks of the "Bell" embankment type. Each protection embankment is 4,000 ft. long, extending 3,000 ft. above the bridge and 1,000 ft. below it (see Figs. 1 and 2). The ends are curved inward and are heavily pitched with stone. The embankment consists of a core of earth raised 18 ft. above the high water level, protected on its river slope with a covering of pitched stone 2 ft. to 3½ ft. thick. From the toe of the slope an apron 4½ ft. wide is spread outwards a distance of 150 ft. As the river cuts away the earth from under the outer edge of this stone, the stone falls and eventually the entire apron will lie at a slope equal to that of the pitched slope of the bank to a depth of 100 ft.—the maximum known depth of bend scour. It has been possible to make these guide banks shorter than would otherwise have been necessary, due to the existence at Sara (three miles above the bridge on the north bank) and at Raita (seven miles above the bridge on the opposite bank) of benches of clay of considerable extent which form semi-permanent points in the banks of the river (see Fig. 1). To render these points permanent, and thus confine the river to a comparatively straight approach to the bridge, they have been reinforced with pitched-stone guide banks and aprons, each 4,000 ft. long.

**Substructure of Bridge.**

**Caisson Foundations.—**The sixteen main piers are founded on caissons sunk by the...