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SOME RELATIONS OF STREAM POLLUTION AND WATER PURIFICATION.

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[A lecture before the Engineering Department of the University of Wisconsin, March 1, 1907.]

I wish to address all the students of Engineering, as well as other students in the University, upon the general subject of the relations of stream pollution and water purification, because it is one in which every good citizen, who is trying to better the conditions of the community in which he lives, must soon take great interest. He will be forced to very shortly in many districts, and if I can develop a principle upon which he can base his thought and action, I will do all and more than I feel myself competent to do.

The civil engineers who expect to devote themselves to municipal and sanitary problems will perhaps be specially interested, and any technical details which I may find it necessary to present will be directly in their line of work, but it is my intention to go into such detail as little as possible and not to get beyond the depth of any of my hearers, but rather to use such detail to make clearer the propositions which I shall try to establish.

I would like to arouse in you all a compelling interest in a vital subject which is becoming each year more prominent, and in the treatment of which you, as a part of the educated engineering contingent in your particular communities, can, if you will, have a larger part, either directly, or, in the case of most of you, in leading public opinion and pointing out the lines on which to travel toward a solution of the problems which will arise.

There are definite relations between the two subjects of stream pollution and water purification, because of the fact that our streams are used and must be used both as drains for the country through which they flow and as sources of water supply for the cities along or near their courses. So long as the country is thinly populated, and especially so long as there are small cities and few of them, the drainage problem is a simple one, and the pollution of streams is seldom serious. The water supply problem is also comparatively simple, for if one stream is not quite safe, another can be found near by, or an underground supply can be utilized so long as the city is small. But large areas of the United States have now become so thickly populated, centers of population and of manufacturing industry have become so numerous, that there are rapidly increasing difficulties in the way of using streams as both sewers and water supplies, and many serious problems are arising every year.

In the nature of things the solution of these problems cannot be left entirely and in every case to the individual cities. There are too many interests involved. The distribution of the expense must often be extended beyond the single municipality. It is usually necessary, therefore, for the state to prescribe the methods of fixing the responsibility for existing conditions and of distributing the assessments of cost. Several states have enacted laws upon the subject, but none have as yet put their legislation into shape such that all cases can be cared for properly, and the expense be equitably distributed. It is the intention to work out here some of the principles which it seems to me are necessary as basis for proper laws, and to show how nearly the laws in some states carry them out. Local conditions must fix the exact form of legislation, but the underlying principles may be the same for all states.

When I was where you young men are in your college course, the question of sewerage was so unimportant that there was no American book on the subject; *Engineering News*, which was then in its early years as a Chicago monthly, published Latham's Sanitary Engineering in supplements and promised an addition to the book, giving data regarding American practice, but was obliged to confess its inability to secure any statements of American methods and to content itself with printing some specifications for the construction of Chicago sewers. There were not more than three sewer engineers in practice at that time and they apparently had nothing new to report; there were probably hardly more than a dozen sewer systems of any extent, and very few cities of more than 100,000 population. The question of stream pollution was therefore of very slight importance. In England, however, there was somewhat greater progress, and the condition of English streams had become such that a special commissioin was then at work upon a study of the problems involved. This commission published several annual reports of progress and recommendations of methods of sewage disposal, and of standards of purity of the water in the streams. Much of the pollution found by this commission was due to manufacturing establishments, and the sewage pollution of streams was comparatively of little importance. The problems are therefore wholly modern, and we must work them out with no precedents of great age to guide us.

The number of public water supply systems in that day was also very small, individual wells being the rule in cities of considerable size. Most of the public supplies were obtained from reservoirs or by direct pumping from the nearest stream, and there were not more than one or two filtration plants in this country, and but few in England.

We will take up first the subject of stream pollution, the beginning of efforts to control it, and the legal limitations of these efforts. The rate of increase of sewage pollution of streams has been very rapid, first because the city population has increased even more rapidly than the population of the country as a whole; second, because the number of centers of population has increased; and third, because the spread of sewer systems has been down into the smaller cities, until now a city of 10,000 population is considered very backward if it does not have some sewers, and there are many cities and towns of much less population which have fairly complete systems.

Naturally the efforts to control this rapidly increasing flood of pollution began in the states where centers of population were close together and water supplies were hard to find. The requirements of the metropolitan district of Massachusetts of necessity made progress particularly rapid in that state, and in that particular district the problems of sewage disposal, water supply and distribution of expense have been well solved. But this is a particular case, and while it is a good example of what can be done, it is not so good an example of how it should be done, the concentrated population, great wealth and restricted areas and facilities making nearly all the problems special in their methods of solution.

For historical purposes, as well as for the later purposes of this paper, attention must be called to two facts: First, that sewage pollution may be so great in amount as to produce a positive nuisance in a stream, and, second, that it may be so slight as to produce no visible effect upon the stream, but may very seriously affect a water supply taken from the stream below the sewer outlet. These two conditions are quite different, and they must receive quite different treatment. They may also have quite different standing before the courts.

The early efforts in England were devoted to reducing the horrible nuisances in the small streams running through manufacturing communities, and the early standards of purity of factory and sewer affluents were merely those which would prevent the creation of nuisances in the streams. In this country the first class of pollution could be taken care of through the board of health or the police department under the general laws concerning nuisances. No small part of my own work when I was consulting engineer for the New York State Board of Health was the investigation of such nuisances, and the recommendation to boards of health, boards of village trustees and city councils of methods of abating them.

Where nuisance only is to be prevented the laws may be made very simple, and the location of the charge for abating the nuisance is easy. It is readily recognized that no municipality or manufacturing establishment has the right to produce such a nuisance, and that it must abate one which it created. However, in some cases, such as that of Worcester, Mass., it took a number of years to fix the responsibility definitely and to secure the satisfactory abatement of the nuisance and return of the stream far enough toward its pristine purity to satisfy the riparian owners below the city. Some of them were obliged to accept the stream as approved by the state authorities, even though it did not conform to their ideas of a satisfactory purification.

The amount of pollution which a stream will stand depends upon a number of conditions. The condition of the stream prior to the entrance of the sewage has some effect. A stream which is already carrying a full load of organic matter cannot receive as great an additional load as a comparatively pure stream. In one instance in my practice, at Deadwood, S. D., the stream was carrying a load of finely divided sand, refuse from stamp mills at gold mines, which was so heavy that the stream could not flow steadily but only by rolling the sand down in a series of waves, making dams which alternately formed, broke, and formed again lower down. In this case the sewage discharged from the city was almost equal in volume to the water in the creek, but the thorough comminution of the solid matters in the sewage by the rolling sand waves and the aeration which it received caused the disappearance of the sewage from sight within a few hundred feet, and it is quite probable that it would not show in a bacteriological analysis more than a few thousand feet down stream. In another case, at Middletown, N. Y., the relative amount of sewage to clean water in the stream was about the same. The stream was dammed and a pond of several acres was formed. The sewage settled in this pond and for some time its effects did not show in the stream below the dam. In a very few years the pond became full of sediment, and then the heavy load of organic matter in the sewage was carried through the pond and deposited in the bed of the stream below. The fine black deposit of comminuted and partly decomposed sewage and the black stain which it leaves on stones in the bed were observed for a distance of five miles down stream, and would probably have shown their effects farther if the stream had not discharged into a river large enough to conceal the pollution on account of the large dilution. This stream was becoming progressively worse on account of the proportion of sewage being too great, so that the organic matter could not be destroyed, but must be deposited in the stream. Had the flow of the stream at flood times been sufficient in volume and the condition of the pond been such that the deposits in it could have been washed out by the flood, the stream below might have remained free of nuisance, as the pond would, after each flood, have served again as a settling, or even as a septic, tank. In another case, a Catskill mountain hotel, the practically undiluted sewage dropped over a waterfall, but the comminuted sewage was deposited on the rocks at the base, and most of the way down where it was kept wet by the spray from the fall and served as the nidus for vegetable growths of various sorts. This was also a progressively increasing nuisance.

Instances of the cumulative effect of discharges of sewage along the course of a stream are numerous. The first factory or private sewer or street sewer has little effect. Another a few hundred feet down adds something and by the time four or five have entered, the stream begins to show the characteristics of a nuisance. Floods clean out the portions of the stream not in ponds behind dams, so that the nuisance may not become serious, except toward the end of a long continued drought, and in two cases which I inspected, this was the only reason sewers to relieve the streams of their pollution had not been imperatively demanded long before.

Large streams develop similar conditions. A recent sanitary survey of White river, made by Professor Sackett, showed that the effects of the sewage of Indianapolis were felt in a physical way for fully twenty miles down stream, and these effects could doubtless be traced by bacteriological and chemical analyses all the way to the junction of the main branches of the river, if not still farther. One interesting feature in this case was the killing of fish by a slight rise in the river. The case is explained as follows: The sewage settled to the bottom in pools where the velocity of the flow was slight, and the decomposition of the organic matter used up all the oxygen in the water standing in the pool below the surface current. When the river rose slightly, on account of rains above, this oxygen-less water was pushed out of the pools and the fish, in their attempts to get away from this polluted and unbreathable water, ran into bayous and up the mouths of small creeks where they were stranded by the falling water and left to die. Fish are numerous about the outlet of the sewer, but are not found below after the organic matter in decomposing has removed the oxygen from the water.

This case is one of many in Indiana which apparently can not be reached by the present laws in that state. There has been at least one decision that the streams are the natural drains of the state and must take what reaches them. A farmer situated some distance below the sewer outlet at Mishawaka sued the city for damages because his cattle would no longer drink the water and he was put to expense to secure a new supply. The court refused the damages for the reason stated. The State of Pennsylvania apparently admits the correctness of this decision in the absence of a statute, since in a recent law requiring cities to have licenses for discharge of sewage into a stream, those having sewers constructed prior to the passage of the act are expressly excepted. New Jersey has an elaborate law providing for a state sewerage commission to take care of the difficulties arising from the drainage of cities into streams, and Massachusetts has a metropolitan sewerage commission for the same purpose.

Discharges from manufacturing plants can be reached more easily, so far as recovery of damages is concerned, partly because the plant is artificial and its effluent can not be classed as necessary drainage, like the sewer system of a city, and partly because the chemicals or solids in the discharged water are poisonous to life in the water, or otherwise directly injurious to it, or productive of nuisance. That is, manufacturing plants belonging to private persons are not given the liberty to discharge their artificial waste into streams, which liberty, with regard to their so-called natural wastes, municipalities enjoy in such states as Indiana. Many more instances might be cited, from the former discharge of Chicago's sewage into the lake from which it derives its water supply to the sewer discharging into the creek under the bridge on one of the principal streets in your own town; but those given will serve as instances of some of the classes of nuisances produced and the reasons for them. It is apparently necessary, in order to abate nuisances caused by town drainage, to pass special laws on the subject. In a state like Indiana, where such laws have been neglected, and the manufacturing establishments have been regulated to some extent under the general law governing nuisances and some special laws, the cities are the great offenders, and they can not be regulated. There are less than a half-dozen states which have such statutes, and therefore there are less than a half-dozen which can protect their people successfully against the nuisances produced by cities and towns in discharging sewage into streams too small to carry it successfully.

The damage done to water supplies by sewage is even harder to reach. It can be prevented only by statute, and there are but few states which have any laws on the subject. Here again the variations in conditions make differences in requirements. Thus a stream might be polluted at its source, but be perfectly safe to use at its mouth, say twenty miles away, because the stream has thoroughly purified itself within that distance; while, in another case, the proportion of pollution being greater or the conditions of the stream being less favorable, the water would be unsafe as a water supply. Cumulative pollution from a series of towns may seriously damage a lower water supply in one case and not in another. It is, therefore, quite impossible to lay down rigid rules which may be applied to every case.

In our examination of the Mohawk river some years ago, we found conditions which will illustrate the statement made. At that time the city of Rome obtained its water supply from the river above the city, and when slightly filtered, this supply was satisfactory, the amount of pollution above being very slight. Utica, Little Falls, Cayadutta Creek from Johnstown and Gloversville, and Amsterdam, with some smaller towns between, added sewage pollution which showed very definitely and in a pronounced manner in both chemical and bacteriological analyses of samples of the river water taken below the outlets of the sewers. The effects of these successive doses of pollution diminished with greater or less rapidity according to the proportionate amount of sewage to water in the stream and the conditions of flow, but did not disappear before the waterworks intake at Schenectady was reached. One comparison where the conditions are as nearly the same as possible, with one exception, will be of interest. At that time Amsterdam and Schenectady had each about 20,000 population. Each had a system of sewers discharging into the river. There were only very small streams discharging into the river for nearly 30 miles below Amsterdam, the distance to Schenectady being some 19 or 20 miles by river. The conditions in the stream were practically the same except as to the method of flow of the water. From Amsterdam to Schenectady the fall in the river is quite uniform and the water runs through a series of riffles and reaches, always with a very perceptible velocity and seldom with any very pronounced aerating drop. The result is a reduction in number of bacteria of about 60 per cent, in sewage bacteria of very little, and in chemical indications of pollution of 85 to 90 per cent. About three miles below the Schenectady sewer outlet is a dam for a feeder of the Erie Canal, which makes a pond about four miles long. Although the dam is on a ledge of rock and is but five or six feet high, the depth of water at the sewer outlet is some 15 to 20 feet with soft bottom. The sewage settles in this pond, which acts to some extent as a septic tank. Below the aqueduct dam the water flows for about nine miles, spread out over a rocky bed, and has a thorough aeration, a sedimentation in the impounding dam of the West Troy water supply and a further flow of several miles over a rocky bed to the Cohoes dam. By this time, some 18 miles of flow, the evidences of sewage disposal have entirely disappeared, the sewage bacteria having disappeared, and the number of ordinary bacteria being less than above Rome. This indicates strongly that the sedimentation and aeration below Schenectady are materially effective in destroying polluting matter, while the rapid flow between Amsterdam and Schenectady is not nearly so effective.

It is not safe to assume that the results, obtained at low water in the summer and fall, obtain at all seasons. Some results at flood times suggest that the purification is not so rapid under those conditions, or, perhaps, that the greater rapidity of flow reduces the time of transit and thus carries the point of disappearance of pollution farther down stream. It is evident, also, that the depth of the river at the Schenectady sewer outlet, for example, must be sustained by the washing out of the deposits by the flow at flood time. While it is probable that the bacteria in these deposits have disappeared almost entirely, and the sewage bacteria completely, this sediment injures the appearance and the potability of the water. The conditions under the ice are different also. Those of you who have read Mason's "Water Supply," may remember his example of the carriage of typhoid fever by the Mohawk river, which occurred during the period of our investigation of the river. As already stated, Schenectady and West Troy obtained their water supplies from the Mohawk river, Cohoes obtained its supply also from the Mohawk, below the West Troy supply, although Cohoes is on the Mohawk river above its mouth, and West Troy is below on the Hudson. Green Island, Waterbit, Troy and Lansingburg are located about the mouth of the Mohawk river and obtain their water supplies from the Hudson. It happened one winter that the Mohawk river was covered with a heavy coat of ice, perhaps 24 inches thick. A flood from an early thaw made the water very muddy, but was not enough to break up the ice. Schenectady people were obliged to use the water from the river unfiltered, if at all, and some of them went back to old wells which had been condemned years before as sources of typhoid fever. As a consequence there were a number of cases of the fever. Shortly afterward there was quite an epidemic of typhoid fever in West Troy. On investigation, the water supply was suspected and arrangements were made to get a supply from the Green Island waterworks, Hudson river water. The epidemic abated and an economical mayor turned on the Mohawk supply without notice to the board of health, to save the extra expense of the Green Island supply. The epidemic again increased until the change was discovered, when a change back again to Hudson river water again abated it. Cohoes also had some typhoid fever, but the epidemic was less pronounced, its intake being some 20 miles by river and canal from Schenectady, while the West Troy intake was about nine miles away. None of the villages and cities getting their supplies from the Hudson had outbreaks of the fever except Albany, which drew part of its supply below West Troy and from the same side of the river, and had an epidemic following that at West Troy. It is proper to state, however, that the Albany health commissioner reported other causes for the fever, and that it was not epidemic in the portion of the city supplied from the Hudson river.

The books on sanitation and on water supply are full of instances of similar occurrences, and it is not necessary to repeat them. It is only necessary for our purposes to call attention to the large and increasing number of such cases. As sewer systems are introduced the density of population increases, and the number of water supplies drawn from surface sources increases. The necessity of taking steps for the protection of the water supplies is thus becoming each year more urgent.

Some discussion of the sources of water supplies and the purification of water is now in place.

As already stated, the larger cities are obliged to resort to surface water, mainly because underground sources are insufficient or inordinately expensive. The history of the Indianapolis water works is typical, most cities passing through several if not all of the stages which will be described.

When the works were established, about 1870, water was pumped from White river at the foot of the main street on the west side of the city and near the middle, measuring north and south. For a few years this supply was reasonably satisfactory, but was never wholly so. As the city grew toward the north and the streams flowing to the river above the waterworks became more polluted, and industrial sources of pollution became more serious, the main pumping station was established just above the largest of these tributary streams, out of reach for some years of the city's own pollution. Here a connection was made with the river by a submerged gallery, supposed to strain the water, and a filter gallery, so-called, was made in the gravel, parallel to the creek, from which water was pumped. Although the gravel bed was so porous that roily water was often present in the gallery at flood times, the voids in it were filled with the fine material in the water and this, with the increase in demand from the city, caused extensions of the gallery, both open and in tunnel, in efforts to make the supply keep up with the demand. Direct draft from the river was resorted to on occasion to supply deficiencies at times of heavy draft for fires, or when the ground water was low and the demand was great, as in the summer season and in the dead of winter. Increasing pollution in the river from the growth of the city itself, from other cities above, from more thickly settled farming districts, and from large and numerous manufacturing establishments caused the board of health to condemn this direct connection with the river, and to look with some suspicion on the gallery supply.

In its search for water the water company drove some wells in the bed of the gallery and found flowing artesian water which served to increase the gallery supply, but an increase in the number of wells reduced the head of the flowing water, and they ultimately failed entirely. The company had purchased a large tract of ground about the pumping station and proceeded to locate deep wells, say 200 to 300 feet in depth, and put them in operation. In these deep wells the water rose near the surface, but when pumped the surface of water in the well dropped a distance which has gradually increased until at the time the wells were kept in full operation it was, I understand, some seventy feet below the surface. It would evidently be impossible to pump these wells by suction from the main pump, and the alternatives were small pumps, one over each well, or the air lift. The latter was selected. The water is very hard, and much of this hardness is due to iron salts. The aeration by the air lift caused much of this iron to settle in the basin to which it flowed from the wells, and thus obviated the necessity of softening treatment. The wells became an expensive luxury to the company, because the air lift is not an economical method of lifting water on so large and constant a scale, because the lift was becoming greater each year, and because the wells became clogged in the course of time, so that it was necessary to put down frequent new wells to replace those worn out, and to meet the additions to the demand. The company finally decided, partly on account of the expense and partly because the city health authorities were complaining of the quality of the water, claiming that river water must be used to eke out the increasing deficiency in the well water supply, to put in a filter plant sufficient to filter all the water used by the city. The water is taken from the river well above the city by a canal some six or eight miles long, and is filtered by the slow sand filtration process. Until enough filter plants are completed to supply all the demand the wells are drawn upon.—This case is an example of most of the points which I desire to make in this paper.

First. The original plant was located where it was soon subject to pollution from the city itself. Naturally, if the plant belongs to the city, the cost of the new plant made necessary by this condition should be paid by the city. Under private ownership it was paid by the company.

Second. The pollution in the stream from what may be termed general sources increased until it approached the limit, and comparatively small additions of concentrated pollution from city sewers and the water-borne refuse from manufacturing establishments carried it over the limit. This general pollution is due to the action of the stream as a drain for its watershed. It would require a certain amount of purification of the water to render it absolutely safe for domestic use, though, without city sewage and factory refuse, it would not ordinarily be considered dangerous. It places on the water plant, however, the practical necessity of some expenditure of money in constructing and operating some kind of filter plant. The general action of the stream as a drain for its district is ordinarily considered a natural one, and there has been no serious question of the duty of the water plant to pay for such purification as it may need. The company has, however, by suits, enjoined such industrial pollution as straw board waste.

In the State of New York the State Board of Health is given power to make rules for the protection of the watersheds of streams used as water supplies, which rules have been applied, mainly, if not entirely, to streams appropriated wholly for water supplies. These rules place upon property on the watershed a burden of expense which adjoining property outside the watershed is not required to bear, but, thus far, it has been justified as a sanitary measure. Such rules were made for the Croton watershed, from which the supply of Manhattan and Bronx boroughs of New York City is taken, and they have been in force for some years over a large part of two counties. There were but few collections of houses on the watershed at the time the rules were made, notwithstanding its proximity to the city. The sewerage of these hamlets was not complete, but was required to be made complete, and the city assumed the expense of purifying the sewage. The city also paid any extraordinary expense of preparing isolated houses for purifying their sewage and keeping it out of the water courses and reservoirs. New residents are obliged to take their property under the burden of the rules.

Similar regulations are enforced on the watershed of the Boston water supply, and the general health laws of New Jersey, Ohio and Minnesota give the State Board of Health power to prevent similar pollution, without prescribing so fully the method of doing so. What could be done under such sanitary police power in protecting the water supply, say of Poughkeepsie, on the Hudson, below many sewered cities and towns, has not yet been tested. It is fairly safe to assume that in such a case the more artificial sources of pollution would greatly overshadow the pollution from the general drainage of the farming districts outside the cities, and that the rules which have been applied successfully to watersheds used exclusively for collecting water for water supplies, with incidentally drainage for the farms and farm buildings on them, would not be applied, even if they were considered desirable. Up to the present time, western states have not developed the state of mind which the more thickly populated states have reached, which makes them willing to submit to such sanitary restrictions as those named, and it is probable that no state legislature west of New York would at this time pass a law like that authorizing the rules referred to. They may come to it some time, but the time is not yet. It may then be assumed that the pollution from the ordinary general action of the stream as a drain for the country through which it runs must be removed at its own expense by the city or company desiring to use it for water supply. Sanitarians are now practically unanimous in their opinion that all surface water supplies should be filtered, the amount of filtration depending on the character and amount of the pollution.

Third. The sewers of cities and towns are the drains of the portion of the watershed which they serve. This drainage is capable of producing a nuisance if the stream into which it discharges is small. It seriously affects the safety of the stream as a source of water supply for some distance, depending on conditions, some of which have been described. If this sewer system is a new one, it is probable that purification could be required by law, if there is a water supply below which would be affected. If it is an old one, put in before the water supply was taken from the river, the case is somewhat different. Prescriptive rights—first in the field—might have some effect on the decision as to whether the water supply should be purified at the expense of its owners, or the sewage should be purified at the expense of its city. Thus far the cases settled have been on the basis of purification of sewage by the city producing it, although the Passaic river water supply of Jersey City was condemned and ordered out rather than to attempt to purify the river by purifying the sewage discharged into it. There is the probability of nuisance in all but the largest rivers, which fixes the cost of purification on the city producing it, so that the large cities will doubtless have the burden of purification of their sewage to carry. It is very doubtful, however, whether a general order to all cities to purify their sewage could be enforced, except where there was definite evidence of permanent and serious injury to interests below, or to the health of communities below, through their water supplies or through the nuisances produced. The problem is one of increasing importance, and states are gradually falling into line and passing laws upon the subject. These laws are usually inefficient, because they are passed without a thorough study of the whole question, and so cover only some special phase of it, which has caused trouble to some one with force enough to get a law passed to attempt to regulate it.

Nearly every phase has been handled in one state or another, and it is here proposed to select various provisions from existing laws, arrange them in proper order, and add the connecting links.

Evidently we need full information about conditions, that we may act intelligently in our effort to improve them. This information can be obtained by such an organization as the State Water Survey of Illinois. This is carried on under a very simple law, the main provisions of which are as follows:

"The Trustees of the University of Illinois are hereby authorized and directed to establish a chemical and biological survey of the waters of the state in connection with said University.

"It shall be the duty of the University to collect facts and data concerning the water supplies of the state; to collect samples of waters from wells, streams, and other sources of supply, to subject these samples to such chemical and biological examination and analysis as shall serve to demonstrate the sanitary condition, and to determine standards of purity of drinking waters for the various sections of the state, to publish the results of these investigations in a series of reports to be issued annually, or oftener, to the end that the condition of the potable waters of the state may be better known and that the welfare of the people of the various communities of the state may thereby be conserved.

"For the installation and support of said survey there is hereby appropriated the sum of $3,000 per annum."

To cover all the ground, this law should also have provision for examining streams into which are discharged sewers or which are desired for use as sewer outlets. The Illinois Survey has attempted to fill some of the gaps in its law, at least temporarily, by making a combination with the U. S.

Geological Survey, the Engineering Experiment Station of the University of Illinois, the Illinois State Geological Survey, and the State Board of Health, whereby the money available is more than doubled and the scope of the work is widened. A special investigation of the effects of pollution in the Illinois river was made through a special arrangement with the Chicago Drainage Board. Reports of the work done contain recommendations that it be officially extended to include investigations of sewage purification and of waste disposal from factories and drains of all kinds. With these additions this department becomes the scientific and technical investigation department, which can study each individual case and be prepared with information and recommendations. The department should evidently be one branch of the work of the authority put in charge of the sewage purification and water supplies of the state, whether this is the State Board of Health or a special commission. Massachusetts, New Jersey, and Vermont have general provisions giving the State Board of Health power to make similar investigations, and New York and Ohio have on occasion made similar surveys of parts of these states without specific direction by the statute.

The next problem which arises is the prevention of additional pollution of the streams and the prevention of the use of water from polluted sources by newly established water plants, private or public. This is the first point of legislative attack, ordinarily, and there are several states which have statutes upon this subject. Those of Massachusetts and Ohio are perhaps the most inclusive, but Vermont, New York, New Jersey, Pennsylvania and Minnesota have provisions similar, though not so all-inclusive as the following, which is in force in Ohio:

"No city, village, corporation or person shall introduce a public water supply or system of sewerage, or change or extend any public water supply or outlet of any system of sewerage now in use, unless the proposed source of such water supply or outlet for such sewerage system, shall have been submitted to and received the approval of the state board of health."

Such provisions insure proper attention to sanitary principles by all new water and sewerage systems, and indirectly and to a somewhat limited extent by systems already established, through the control of additions and changes which may become necessary. This Ohio provision is producing excellent results, and, with the sections of the law governing the refuse from manufacturing and other industrial plants, seems to be able to control the situation, so long as the state board of health is an honest and capable body, which meets the demands of science and business capacity which are made upon it.

In the State of Indiana there has been an attempt to reduce the control of stream pollution to a scientific formula, presumably to remove the opportunity for undue influence which is possible under statutes like that of Ohio, where the decision upon each case is left entirely to the discretion of the state board of health. The proposed Indiana statute starts out with a definition of pollution, which was, I believe, prepared by engineers on the United States Geological Survey, and is thoroughly scientific in its construction. It reads as follows:

"The term polluting substance shall be construed under this act to include—

"(a) Any liquid which contains a greater number of parts by weight of suspended matter or of the salts of calcium, magnesium, iron, sodium, and potassium, than that normally carried by the rivers in the country immediately surrounding, or any liquid possessing an acidity greater than that which would be produced by adding 20 parts of standard chemically pure hydrochloric acid to 1,000,000 parts of distilled water, except in cases where it can be shown that greater amounts of suspended matter, or of said salts, or a greater degree of acidity does not create damage to natural waters;

"(b) Any liquid which contains a greater proportion of metallic arsenic than 0.1 parts in one million parts of water;

"(c) Any liquid which contains a greater proportion of metals or metallic salts, other than those herein specified, than 20 parts in 1,000,000 parts water;

"(d) Any substance which becomes putrescible after incubation for one day at 37 degrees Centigrade, the index of such putrescibility, after such period, being an insufficiency in the amount of oxygen, free or in organic combination, in such incubated sample to combine in stable form with all the organic carbon and nitrogen present."

This section is intended to cover all classes of pollution, domestic or public, manufacturing or drainage, and certainly does so. The first section of the proposed act would make it "unlawful for any person to put or cause or permit to be put or carried or to flow into any stream or lake in the State of Indiana any polluting substance, so as, either singly or in combination with other similar acts of the same or any other person, to pollute the rivers of said state." The only discretion allowed the board under these two sections is in the words, "except where it can be shown that greater amounts of suspended matter or of said salts, or a greater degree of acidity does not create damage to natural waters," and this power of choice is extremely limited. It is possible that this definition of pollution is an attempt to apply to the protection of water supplies the principle, referred to earlier in this paper, which was applied to English rivers, grossly polluted with manufacturing refuse. In that case the permissible pollution was comparatively great, and the nuisance it was intended to reach had become unbearable. The district was also thickly studded with factories, and such a requirement operated on all alike. The fact is, however, that there were several definitions of allowable pollution which were formulated for the several districts under consideration, and there was no attempt to make a single standard applicable, without recourse, to every case.

Such a definition as Section 2 of the proposed Indiana law gives, if applied indiscriminately as the bill proposes, would work much hardship. It may well be made a misdemeanor to throw an apple core into one stream, because, in combination with other polluting matter thrown into the stream it might injuriously affect a water supply, but in other cases this would be the logical method of disposal of the apple core. The state board of health would have little discretion regarding the appreciation of the definition in the two cases. The earlier part of this paper has shown many other reasons why the regulation of the pollution of streams must, for many years, at least, be subject to great discretionary powers of the body having the sanitation of the state in charge. It is needless to say that this proposed law was promptly killed by both houses in the legislature in which it was simultaneously introduced.

The application of new laws to streams already polluted by established systems of drainage, sewerage and refuse disposal is a matter which seems to require delicate handling in the legislature. This country, during its development, has fallen into the habit of considering that the first comer has prescriptive rights which no one coming after him can abridge in any manner. This doctrine has in some cases been carried to ridiculous extremes, and if local public opinion sustains a man, he can, in some of the new states, hold, almost by force of arms, rights to which he has no claim except that of assumption of them in the absence of any one else, or prior to the arrival of any one else. In the irrigation field there is a reaction against too strict an application of this doctrine, and a prior right to water from a stream can now, in many districts, be enjoyed only to the extent that it can be profitably used without waste on the lands actually controlled by the owner of such prior right. This is quite a revolution, but is one which is based on correct principles.

Prescriptive rights of cities and factories are recognized in the statutes regarding stream pollution in the various states. The provision in Massachusetts shows most clearly the influence of local interests in the formation of statutes so as to protect these "vested rights." It says: "The preceding sections shall not be construed to destroy or impair rights acquired by legislative grant prior to the first day of July, 1878, or to destroy or impair prescriptive rights of drainage or discharge to the extent to which they lawfully existed on that date; * * * nor shall it be applicable to the Merrimack or Connecticut rivers, or to so much of the Concord river as lies within the limits of the city of Lowell."

Vermont provides that prior rights of drainage of houses, etc., shall not be interfered with, unless the corporation or company complaining of the pollution of its water supply shall pay the expenses of any necessary change. As already stated, this is the effect of the court decisions under the New York law for protection of water supplies, where it has been thoroughly tested.

Perhaps one reason for the prompt suppression of the proposed Indiana law was its treatment of this subject. No distinction was made between prior and subsequent pollution, and complaint could be made and investigated without reference thereto. The final appeal could be made to the local courts, and the final decision as to the removal of the causes of complaint and the placing of the responsibility for the expense of the change was left to these courts. This would put the decision of each case upon its merits, and took the necessary judicial features of the abatement of pollution out of the hands of the scientific authority, which determined the validity of the complaints, and supported the sanitary claims for a change in conditions. By omitting the definitely stated exception of prior rights from the statute it was made possible to treat many cases which would be out of reach under the statutes of the other states referred to. This part of the proposed Indiana law is a pronounced advance upon the practice in other states, and I wish to commend it particularly to the attention of those who may have something to do with the formation of similar statutes.

There is another matter of importance which is emphasized in the Indiana measure,—the cumulative effect of various sources of pollution.. It is probably possible under the statutes in some of the states for one corporation to escape from liability on the ground that the pollution from the one source is not serious, while its combination with others gives rise to a nuisance, or to a condition which makes the water dangerous to use for domestic purposes. This Indiana bill might be strengthed somewhat by carrying this provision still farther and providing for a determination by the state board of health, or, preferably, the court, of the responsibility for the condition, and for a division of the expense of correcting it among the parties interested, including both those who pollute the water and those who wish to have it as clean as possible for use for domestic or manufacturing purposes.

There is one other important matter in the construction of a statute concerning which something should be said, that is, the appropriation for carrying it out. It is sometimes possible to get a very satisfactory statute adopted, provided the appropriation which it carries is not insisted upon too strenuously. The ordinary legislator understands the financial side, but has little knowledge of the scientific side. If his prejudices are not aroused, he can often be induced to vote for a good law which he does not understand, on the word of the scientific men of the state, especially those in the state administration. In most states, at the present time, the movement to restrict stream pollution is largely educative, and it may be well to accept a statute with an appropriation which is wholly inadequate, with the hope, and the expectation, that the educative work which can be done under it, and the special reports on the most flagrant cases, will lead within a few years to appropriations sufficient for the needs of the state in this regard.

As examples of different methods of treating the question Ohio and Indiana may be cited. In Ohio a start was made by securing a small item in the general appropriation ordinance providing for a special investigation. This was increased from year to year until the desirability of a more specific law was shown. The passage of this law in a rather ineffective form was the next step, and this law has been strengthened from time to time, as opportunity offered, until Ohio now, after some fifteen or twenty year's development, has one of the best laws in existence, and a public opinion behind it which will warrant further strengthening in the future, until the subject is fully covered.

Indiana tried not long after Ohio got its start to secure the passage of a comprehensive law, intended to cover all branches of the subject. The bill was a good one and it was a pronouced advance upon any legislation then in effect. It was too good and required too great an appropriation to administer it. As a consequence it was turned down by the legislature. During the intervening years, one or two of the provisions of that bill have been passed in modified form, such as the state laboratory, and this year an attempt was made to pass the stream pollution law already referred to. This again was too far in advance of practice in other states, and very much too far beyond the public opinion in Indiana, and the bill was reported out of committees for indefinite postponement, so that it did not serve even as a subject of discussion, which might have had an educative effect. The moral apparently is, not to attempt very much at any one time, unless there is some special condition of the public mind which will carry through any measure which might be presented.

The best success seems to be obtained by attacking the subject in about the order in which it has been developed in this paper, although the first two steps have several times been taken together.

In case there is a state college laboratory already established, it is comparatively easy to secure the establishment of the water survey, such as Illinois has in operation, and the question of sewage disposal can be included also without much difficulty. With the body of information obtained from such a survey the subject of control of water supplies and sewerage systems can be attacked with some hope of success with the legislature. The provisions in such a law can then be strengthened from time to time, until the whole subject is covered.

No special attention has been paid in this paper to such legislative creations as the Metropolitan Sewerage and Water Boards of Massachusetts and the various sewerage commissions of New Jersey and New York, because they have been established to meet special conditions, and are not bodies for which other states have much use at present. However, there are some provisions in the statutes governing them which can be used to advantage in the formation of general state laws, and a study of them will be of great assistance.

AN UNDERGROUND CAMERA.

J. T. Atwood, University of Wisconsin, Madison, Wis.

Introduction.

An underground camera for photographing the sides of well holes, so far as the writer knows, has never been made. However, it seems probable that such a camera has been used because of the value of photographs of the earth's foundation at levels reached only by drill holes. With the belief that such photographs would be of value in scientific research and in commercial mining work, the camera herein described was designed and built.

Description of Camera.

Plate No. 1 shows the apparatus complete. The camera is mounted in the lower end of a water tight tube. This tube is 5 inches outside diameter, and 43 inches long. Near the upper end of the tube is a plate glass window with a mirror back of it, so mounted as to reflect the image of an object placed before the window directly down the tube and into the camera. On either side of the mirror is mounted an electric lamp with a reflector, which sends the light through the window, and also prevents any light from shining directly into the camera. This iron tube or camera tube is lowered and raised in the well by a cable winding on the lower of the two drums shown in the photograph. The upper drum carries an electric cable to operate the lamps and to turn the camera film. The cable is so fastened to the tube that the window will come close to the wall of the well, and with the lights burning, the wall is brightly illuminated. In making an exposure with a No. 16 stop, the lights are turned on for about 20 seconds. Before making a second exposure the camera tube is lowered or raised $4\frac{1}{2}$ inches, the distance covered by one photograph, and a new part of the film is turned into place by making and breaking the circuit of an electro-magnet acting upon the roll of film. In this way a series of 50 or more photographs can be taken at the rate of one a minute,

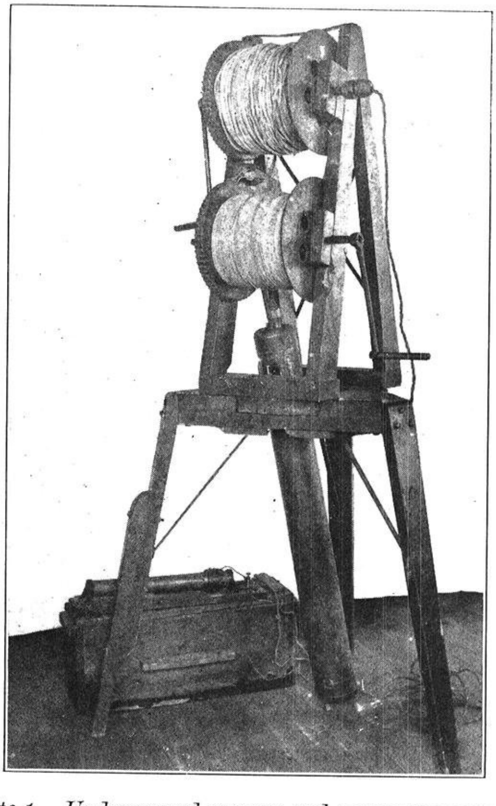


Plate 1. Underground camera and apparatus complete.

and they will show a continuous strip of the wall of the well for a distance of 20 feet or more. Having considered, briefly, the principle and method of operation, the apparatus is considered more in detail in the following paragraph.

Plate No. 2 shows the camera tube with the camera, mirror, lamps and reflectors removed and laid alongside in their relative positions to each other. The window, which is $1\frac{1}{2}$

by $5\frac{1}{4}$ inches, is set in litharge cement. A guard strip is riveted to the tube on either side of the window. The hoisting cable is attached to the hook 4 inches back of the window, so that in the ordinary 6-inch drill hole the window always hangs close to the wall. The mirror, lamps and reflectors are mounted on an oak plate, which can be adjusted to bring the mirror in the right position behind the window.

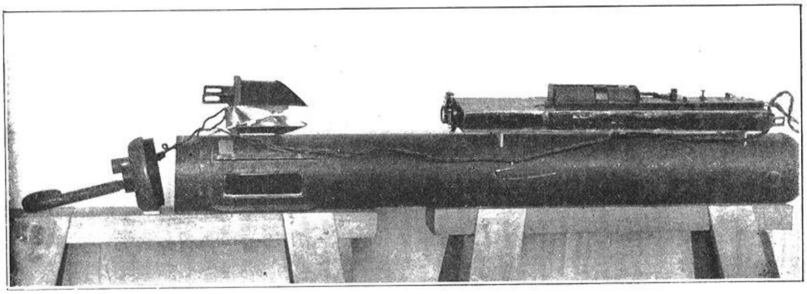


Plate 2. Camera tube with camera, mirror, lamps and reflectors removed and laid along side in their relative positions to each other.

The two lamps are 10-volt lamps and 5 c. p. each. The camera, which is shown more in detail in plate No. 3, is 22 inches long and $4\frac{3}{16}$ by $1\frac{5}{8}$ inches in size. It is fitted with a 9-inch Bausch and Lomb rectilinear lens. The camera is placed in the tube so as to photograph the $4\frac{1}{2}$ inches of wall reflected in the mirror upon $3\frac{5}{8}$ inches of film, the maximum length obtainable with a width of film of $1\frac{1}{4}$ inches. This reduction gives a photograph $\frac{8}{10}$ full size. The camera is fastened in the tube by two thumb screws. One side of the camera is fitted in grooves, and is easily removed for changing the film. (Plate No. 3.) The film winds from the end roll across the flat plate where the exposure is made, and is wound onto the other roll by the operation of the electromagnet acting through an arm and pawl upon a ratchet wheel. The wires for the coil have a plug connection at the bottom end of the camera. A three-conductor cable of No. 14 wire and 250 feet long carries the current from four small double storage cells. A resistance coil is used to adjust the voltage for the lamps before lowering the camera tube. Connection from the cable to the battery and switches is made by a triple plug in the end of the shaft of the winding drum. (Plate No. 1.) The hoisting cable is heavy clothes-line of small twisted wires, tested to over 500 lbs.

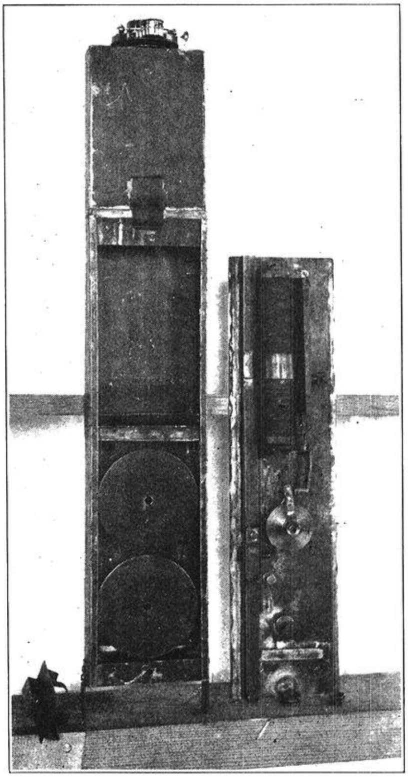


Plate 3. Camera with side removed.

tension. The drum is wound with 300 feet of this cable, and has length tags soldered to it at five-foot intervals. The ratchet on the drum has a double pawl, permitting of $\frac{1}{4}$ inch changes in the position of the camera tube. The hoisting frame is made in two parts, partly to facilitate handling, but primarily to permit of an easy means of untwisting the two cables when raising the camera tube. As can be noticed in plate No. 1, a ring on the bottom of the upper part fits into a corresponding recess in the top of the adjustable tripod or stand. After the first untwisting of the cable there is little need for this turning device. No attempt has been made to record the direction in which the camera hangs. This could be done by using a light stiff rod carefully joined and allowed to stand without any weight or torsion upon it. Another way might be to use a brass camera tube, and to mount a magnetic needle to show in the photograph. With this description in mind we may consider the field work undertaken and the results obtained.

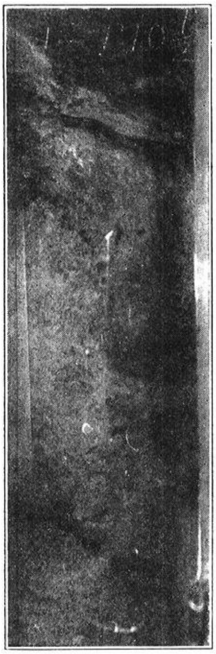
Field Work.

The field work done with the camera has been necessarily limited to a little over a week's time. Because of unexpected difficulty in effectively drying the air in the tube, the results obtained are incomplete, but satisfactory in showing that good photographs can be taken in a well hole both above and below water. The camera was operated in a 200-foot, 6-inch prospect hole upon the Vinegar Hill Mining Company's property about seven miles north of Galena, Ill. A very careful sludge record had been made of this hole, and zinc ore was shown in different amounts at several levels from a depth of 162 feet to 200 feet. Water stood at about 85 feet from the surface.

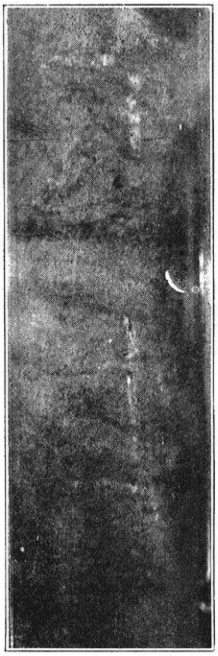
The first attempt in taking photographs under water resulted in securing good photographs. The camera was filled with dried air by forcing the air through a bottle of sulphuric acid. Calcium chloride was desired to aid in the drying, but could not be secured. After lowering the camera tube into the water it was raised to the surface to see if in cooling any moisture had been precipitated on the inside of the window. The window was found dry and clear, and upon lowering it the second time the exposures were made without any regard to the location of ore bodies. Following this, attempts to take photographs under water were made at the first lowering of the camera instead of at the second, and were unsuccessful because of a precipitation on the inside of the window which invariably disappeared before the camera came to the surface, and which did not appear upon the second lowering into the water, as was the case when the first photographs were taken. This fact was proved later in experimenting in water at the surface. That the unsuccessful results were not due to cloudy or muddy water was clearly shown by the clouded effect on the negative being a little uneven, and the same in exposures at different levels. Also a little opening in the precipitation on the window showed the wall of the well in one or two of the photographs. Unfortunately, circumstances prevented any further work after this experimenting was done.

Results.

Photograph (a) was taken at a depth of 170½ feet, and (b) at a little greater depth. The foundation is evidently limestone with a little disseminated ore shown near the bottom in (a), and a narrow sheet or seam near the middle in (b). (See next to last paragraph under heading, Use of Photographs in Well Holes). Photographs (c) and (d) were taken above water, and they are but the first two of a number taken which show a continuous strip of the wall of the well. The foundation is limestone. Photograph (e) was taken on the surface. It is one of a number taken to study photographs of ore bodies. The conditions of water, light and distances were similar to those met with in a well. As a part of this article, it serves to show that a photograph taken in a well is in every way as clear and distinct as one taken under ordinary conditions of photography. The specimen shown in the photograph has a naturally split or broken surface which gives sulphide joining limestone. The line of juncture is very irregular and undefined except where a line of felspar separates the two for a short distance. (See (1) in photo-



(*a*)
Depth 170½ ft. Depth under water 85 ft.



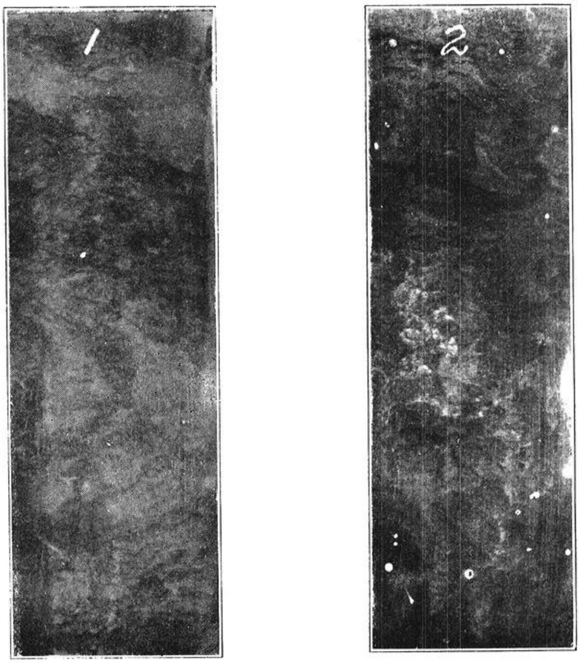
(*b*)
Depth 172 ft. Depth under water 86½ ft.

graph.) The two materials mix in joining and make most of the line as shown ⅜ of an inch wide. Surface (2) is limestone and surface (3) is jack. From the experimental work done and the data secured, it is shown that reliable photographs in a well hole, both above and below water, can be quickly taken, and in most cases at little cost. Further work showing the practical value of such photographs will be undertaken at an early date.

Use of Photographs in Well Holes.

In mining work, prospecting for non-precious metals, such as copper, lead and zinc, is generally carried on by so-called "Churn drilling," or by diamond core drilling. The principal information given about the ore bodies encountered is found in the material taken from the hole. In churn drilling this material is removed in the form of mud or sludge, and in diamond drilling in the form of a broken core. Let us now consider the prospect of drilling for lead and zinc ore.

When a piece of land is thought to be underlaid with ore it is common practice to drill a large number of test holes



(c) *and* (d) *The first two of a series taken above water level showing a continuous strip of the wall of the well.*

and by the information secured, determined the feasibility of sinking a shaft for the purpose of starting a mine. Where a large sum of money is necessary to sink a shaft, it is evident that much is dependent upon the information given by the drill holes. The ore is generally found in horizontal and inclined sheets, called flats and pitches, or in small particles widely distributed throughout the limestone called disseminated ore. The sheet foundations are, as a rule, more extensive, and where a flat or pitch is cut in drilling it is more indicative of large ore bodies than a strike of disseminated ore. If in drilling it were possible to recover all the material in the path of the drill the sludge would give a good indication of the character and amount of ore passed through. However, the sludge often amounts to no more than 2 or 3 per cent of the volume of the hole, because of crevices and

(e) *Specimen of limestone and jack.*

pockets, and the consequent loss of sludge in these openings. The 2 or 3 per cent of sludge may be largely mineral, but because of a lack of knowledge concerning the 97 or 98 per cent missing, very uncertain and unsatisfactory information is obtained. Again, in drilling through solid formation when the sludge is brought up from one, two or three feet of drilling it may be that it shows a fair percentage of ore. The question naturally arises whether the deposit is disseminated or sheet ore. The question is not answered by further drilling, because for a considerable distance after cutting a sheet, pieces of ore are knocked down by the drill and, mixing in the sludge, give the impression that the drill is passing through a body of disseminated ore. In a like manner, when the sludge shows that a sheet of 2, 4, 6 or more inches has been cut, it is impossible to determine its real thickness, and the indication shows it thicker than in reality. When a drill cuts or follows a pitch the indications as to the real amount of ore are enlarged and unreliable, because of the slope, in addition to the other causes. In diamond drilling, the largest part of the core is often lost in passing through ore bodies.

However, the core shows whether the deposit is sheet or disseminated ore, and, in case of a sheet deposit, the core shows its slope and something as to its thickness. Although the information is more satisfactory than with the churn drill, the cost is at least three times as great. The photograph serves to reveal information which can be obtained in no other way from the well hole.

The important information which the photograph may give about ore deposits, which cannot be secured in the sludge record, is as follows. First: The nature of the deposit, whether it be sheet or disseminated ore, and Second: In case of a sheet deposit, the exact thickness and pitch. This information will be of the most value in connection with the sludge record, which cheapens the cost of the photograph in locating the ore, and what is of far greater importance, gives the iron properties of the ore. Such information as given by a photograph is important, and consequently the possibilities offered in the camera are of great value to the prospector and mining engineer.

To an inexperienced person a photograph of ore or ore bodies shows but little about the physical and mineral properties. Much of the information given by colors, or by differences in light and dark surfaces, as seen in the ore by the eye, is lost in the photograph. It is in the crystalline structure that the photograph is able to reveal the nature of the rock or ore, and by study and experience positive information is given very much as by the ordinary eye examination. The character of the surface of the wall of the well is favorable for photographic examination. The roughness is largely dependent upon the character of the material, and makes easier the detection of ore at the juncture with rock.

This discussion, though rather brief, points out some of the advantages in photographic examination of ore bodies through well holes, and shows some of the possibilities which lie in this line of work.

SOME RECENT ADDITIONS TO THE TECHNICAL EQUIPMENT OF THE CHEMICAL ENGINEERING LABORATORIES.

JUDSON C. DICKERMAN, University of Wisconsin.

Pursuing the policy of equipping the chemical engineering laboratories with such technical apparatus as will enable our students to study and investigate problems in applied chemistry, and acquaint them with the workings of such appliances as are used in the technical world, a number of new machines and pieces of apparatus have been recently installed.

For the work in industrial or manufacturing chemistry the most important additions are as follows:

A square plate and frame filter press and a montejus.
A steam-jacketed vacuum pan and still.
A vertical copper tube condenser.
A high pressure steam digester and still.
A direct acting steam vacuum pump.
A vacuum dryer, steam heated.
A rotary roaster.

To enlarge the facilities for work in technical gas analysis the department has acquired

A five cubic foot meter prover.
A complete "London Gas Referees'" apparatus for the determination of sulphur and ammonia.
A Humphrey instantaneous hot water heater.
A special two-light "dry" gas meter.

The above new equipment added to the several grinding mills, gas furnaces, and full line of apparatus for the analysis of gas and fuel, will allow of a wide range of experimentation along chemical engineering lines.

The filter press, Fig. 1, was built especially for this department by D. R. Sperry & Co., of Batavia, Ill.

It is made of cast iron, with each plate surface one-half a square foot in area, and each frame space equal to $\frac{1}{24}$ cubic

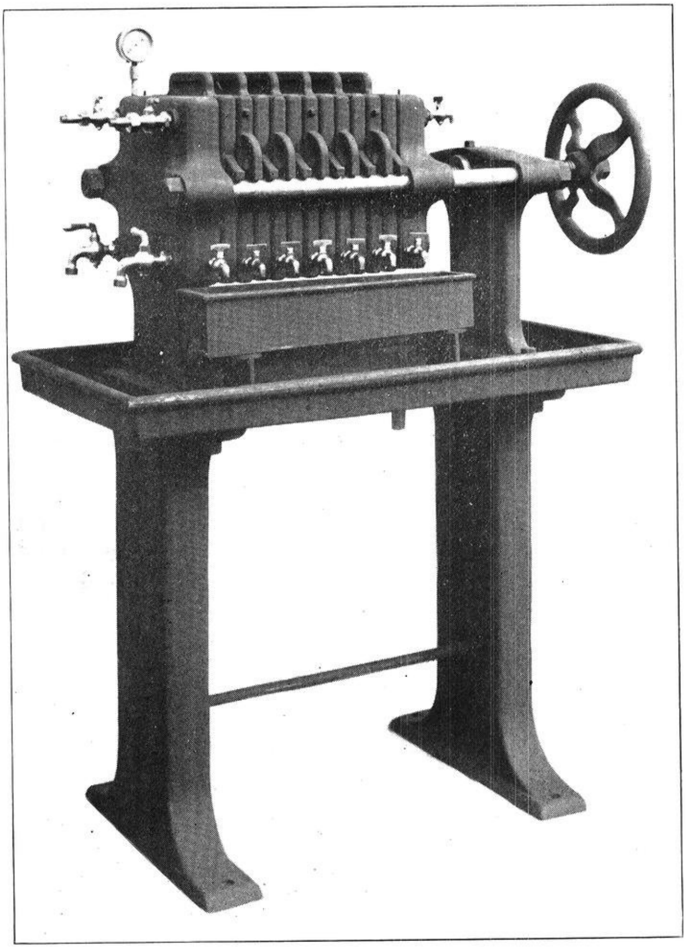


Fig. 1

foot. It is so arranged that volatile or oxidizable solutions may be filtered and discharged through an internal channel, away from contact with the air, or, for ordinary solutions, the filtrate may be discharged into the open trough, where the completeness of the filtration may be seen at once.

It is also arranged for "absolute washing," or extraction. As this press is an exact model of a full-sized press of the most modern type, data concerning the best pressure, most effective filtering medium, bulk of the compacted solid residue, volume of wash liquor or extraction solution necessary, physical and chemical characteristics of the residue or cake, and many other items can be obtained and used with confidence in the design of a plant. The press is available for filtering any substance which will not seriously corrode the iron, such as causticised soda ash, sugar, various salts, etc.

As a means of forcing the turbid solutions into the press, a montejus, or pressure tank, which works on the principle of a chemist's wash bottle, has been installed. Either steam or compressed air may be used to exert the necessary pressure. The piping is so arranged that the solution may be heated with steam before filtering. The montejus also serves as a convenient dissolver where heating and agitation under pressure are desirable, and the dilution from the condensed steam can be neglected or allowed for.

The Vacuum Pan, shown in Fig. 2, was also made by Sperry & Co., especially for this laboratory. It is made of cast iron, with a capacity of ten gallons. It is provided with vacuum gauge, sight holes (through which the progress of the evaporation may be watched), vacuum breaker and fat cup. It is designed to be used as a vacuum evaporator, a plain still, or as an open boiling kettle. For the latter purpose, the dome must be removed from the kettle. To accomplish this, a rather unique devise is used. The dome and its exit pipe are supported from the ceiling at the proper height. The supporting legs of the kettle set in a frame which is carried on four long screws, connected by a link belt. The kettle is raised to or lowered from the dome by revolving the screws. The screws are supported on a carriage moving on a circular track whose center is directly below the vertical steam pipe. By use of swivel joints in the steam pipe, the kettle may be run out from under the dome or returned there while steam is still on the jacket.

This apparatus may be used for concentrating lyes, crystallizing sugar under vacuum, distilling alcohol, acetic acid, ammonia, and many such solutions.

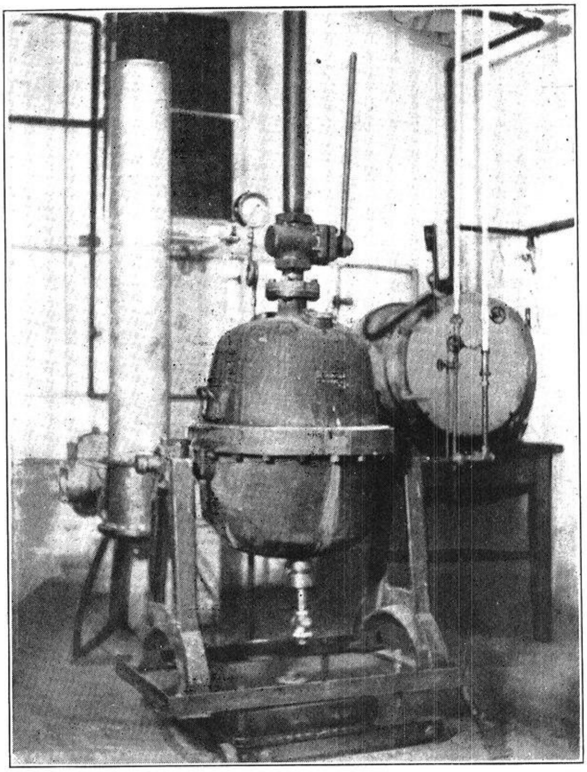


Fig. 2

The copper tubular condenser was built by the University mechanician's department. It has 24-$\frac{5}{8}$″ tubes 6 feet long. The top is removable, so that the tubes may be brushed out if ever badly soiled by a batch boiling over from the vacuum pan. Also any desired number of tubes may be plugged to reduce the capacity of the condenser, if desired. This condenser, together with the vacuum pump, are of ample capacity for any work likely to be undertaken in these laboratories.

The Steam Still and Digester is arranged to be heated with high pressure superheated steam, either through a jacket or directly by live steam. It also can be operated under vacuum. It may be used for distilling turpentine from pine wood, for treating wood, straw, etc., with soda for manufac-

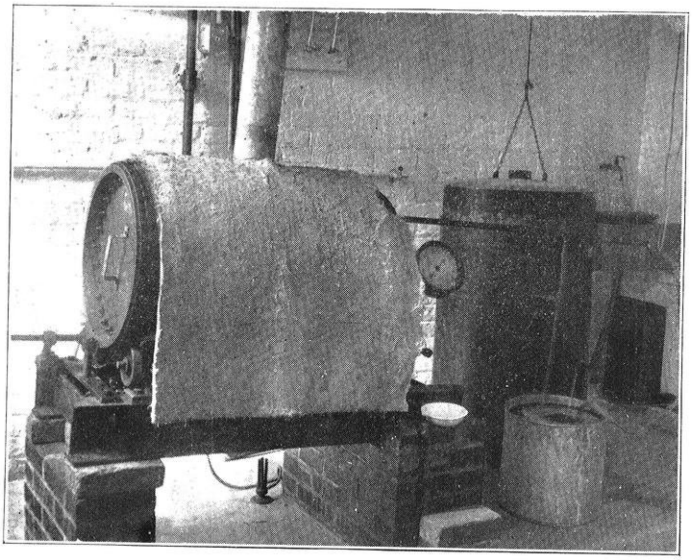


Fig. 3

ture of paper pulp, impregnating wood with preservatives, and other similar processes.

The Rotary Roaster is a copy of a type of furnace operated in several processes by the writer. It is designed for rather low temperature roasting or calciming, where constant agitation and even heating out of contact with the fire gases is necessary. It can be readily converted into a closed retort for the destructive distillation of wood, peat, etc. It is heated by large gas burners. (Fig. 3.)

The Gas Meter Prover, shown in Fig. 4, is a very finely built machine. It is calibrated in tenths of a cubic foot up to a total capacity of 5 cubic feet. The equipment includes the necessary connections and orifices so that any gas meter of from 1 to 50 light capacity can be accurately rated under standard considerations. Attention may be called to the involute, with small weight suspended from it, attached to the pulley shaft.

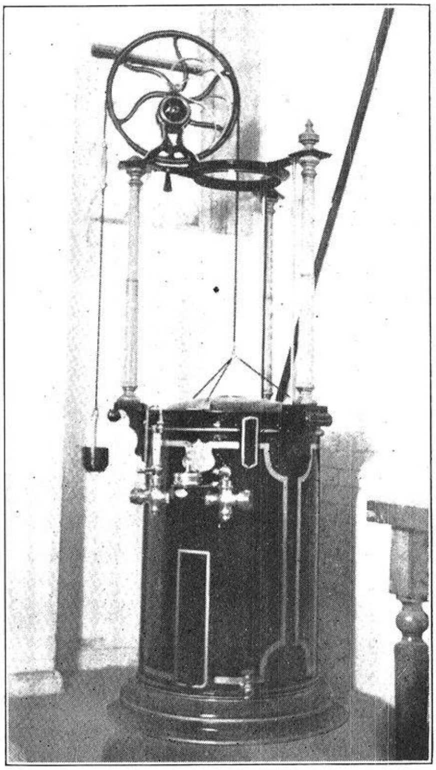


Fig. 4

This is a device compensating for the difference in the weight of the movable dome or bell, as it rises or sinks in the water in the sealing tank. This insures the same effective pressure exerted on the contained gas at all positions of the bell.

"The London Referee's" gas testing apparatus is the standard for determining sulphur and ammonia in illuminating gas. It consists of a gas meter fitted with an automatic shut-off valve, or pressure regulator, an NH_3 absorption bulb, a special gas burner, and an absorption tower. When connected up, the burner regulated, the automatic valve regulator set for the number of cubic feet of gas which it is desired to burn, the apparatus may be left to itself over night if desired, and at one's convenience, the contents of the absorbers may be analyzed for S and NH_3.

The department is planning to make searching tests of the commercial appliances using gas as fuel. As a step in this direction an instantaneous hot water heater has been set up, and connected to a special meter. The efficiencies of this commercial adaptation of the Junker calorimeter operating under different conditions will be compared with the results from the standard Junker. Particular attention will be paid to the loss in efficiency occasioned by continued usage.

From the above descriptions, it will be seen that a broad range of technical experimenting is even now open to the chemical engineering student. During the summer more apparatus will be added to further enhance the opportuuities for investigation along chemical engineering lines.

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EDITORIAL.

In a recent issue of the *Electric Journal* appeared an extract from an address delivered by Mr. Ph. A. Lange at a dinner of the Engineers' Club, of Manchester, England. Mr. Lange was speaking of what he considered to be the most important event in the history of electrical development, and said that after due thought he had come to the conclusion that this most important event was the entrance of the technically trained college man into the field of electrical work. He described some of the methods in use in early days, and then showed how, when the man with the technical training came into the work, the amount of time and labor necessary to obtain data for construction was cut down from weeks to days, and, in some cases, to hours, simply because the technical man was prepared to obtain by calculation the results which heretofore had been determined by experiment.

This seems to be true in the branches of engineering other than the electrical. The demand for technically trained men is just as great among mechanical and civil engineers. This is shown by the fact that practically every man in the Senior class has his position assured, and in some cases, men have gone out into practical work without finishing their courses or waiting to obtain their degrees. The large engineering companies, like the General Electric Co., the Chicago Telephone Co., the Western Electric Co., etc., have sent their representatives here, and to other schools, in order to influence college trained men to take employment with their respective companies. The companies almost seem to vie with each other to make the most attractive propositions to students, and it is certain that even if a man does not stay in such employment long, the experience he gains will be of inestimable value to him; and in many cases he can bring new ideas and new methods to his employers, no matter what branch of engineering he may take up. In any case, with the present outlook, the successful future of the well-trained technical man seems to be assured.

In pursuance of the policy inaugurated last fall of giving the underclassmen some practical ideas of what an engineer is supposed to do, various members of the faculty have spoken to the freshmen and sophomores during the past two months. These talks have taken up the different branches of engineering, and have proved of interest to all who attended, whether underclassmen or upperclassmen. On April

23d Prof. D. W. Mead discussed the subject, "Some Phases of the Work of a Civil Engineer," and confined himself principally to the work of the hydraulic engineer. Prof. Mead is one of the foremost hydraulic engineers in the country, and gave many practical suggestions in connection with that line of work. On April 30th Prof. Storm Bull spoke on "Modern Mechanical Engineering." He spoke of the opportunities for mechanical engineers, and emphasized the need of a thorough preparation, both along all engineering lines and in the fields of general knowledge, if one is to be successful. He urged the students to learn how the work is done rather than how to do it, and advised them to become familiar with at least one foreign language, so as to be able to follow the developments in other countries. At a later date Prof. W. D. Pence spoke on the work of the railway engineer, and gave many practical suggestions regarding the requirements for those in such employment. These lectures are of great value to the young engineers, and the efforts of the faculty to give the underclassmen some idea of the work they are to take up are heartily endorsed by all interested in the matter.

Next year, when the present Junior class are thinking of something to give as a Senior Engineer "stunt," it might be well for them to consider something of the nature of some entertainments which have been given by various other schools within the past few months. This is a real Engineering show, with all the attractions strictly engineering. With the facilities at hand in the various laboratories it would be possible to arrange a great many novel features, both popular and instructive. It was shown at the faculty banquet for Prof. Jackson in February that we have the material here for many such things, and with the right management such a show could be made a great success. The faculty would undoubtedly be glad to help out in such an enterprise, because of the fact that it would be a good advertisement for the College of Engineering, and also because they could derive considerable pleasure from it for themselves.

For several years past it has been the custom to have, sometime during the second semester, a lecture for the Senior Electricals on the methods of resuscitation after electric shocks. It is of the greatest importance that every one whose work takes him around electric machinery or electric circuits of any kind should have some knowledge of these methods. Since the many branches of engineering are so closely allied and because there are so many other accidents which an engineer may be called upon to care for, it was decided this year to have a series of three lectures dealing with first aid to the injured, and have them open for all engineering students. These lectures were given by Dr. W. S. Miller, Associate Professor of Anatomy, and covered the care for all kinds of accidents, from the simple bruise to the most serious accidents which are likely to occur in machine shops or about machinery. The subject is one of the most practical and the lectures proved exceedingly interesting as well as instructive.

On Friday afternoon, April 19th, the faculty and students of the College of Engineering had the privilege of listening to a very interesting lecture by Mr. W. P. Snow, of the B. F. Sturtevant Co., Hyde Park, Mass., on "The Construction of Large Plants." Mr. Snow took up the design of the plant as a whole, then went over each part separately, showing how each part depended on the others, and how the design must be gone over and over until all features are found to be those best suited for the purposes for which they are intended. The talk was illustrated by various lantern slides, and was in all ways most interesting and instructive.

ALUMNI NEWS.

All of Wisconsin's engineering students and alumni will be glad to learn that, at the recent meeting of the American Electrochemical Society, Prof. C. F. Burgess, of the Electrochemical department, was elected president. The distinction which thus comes to Prof. Burgess, and incidentally to our Engineering College, can be fully appreciated only after we have stopped to consider the importance of the society and the industry which it was designed to stimulate.

With the rapid progress made in all fields of pure science during the past few decades has come a very vigorous growth of allied industries. Perhaps no industry of this kind has made more rapid progress or offers better prospects for the future than that of applied electrochemistry.

The industry is a new one, and yet, within a comparatively very short time, it has reached gigantic proportions, the value of the products of electrochemical works in the United States alone amounting to no less than $200,000,000 annually.

Growing parallel with the industry is the organization of the American Electrochemical Society. This society comprises all the foremost men in the Electrochemical field in this country, and includes among its honorary members some of the most prominent men in the same field in England and in Europe. The organization, though but five years old, has already enrolled seven hundred members.

Thus, when we view the society in the light of its rapid growth, and the growth of the industry it represents, we can, in some measure, appreciate the honor the organization has conferred on Prof. Burgess, and we can but congratulate its members upon their choice of one so worthy.

Mr. C. F. Graff, '05, is a consulting engineer in Seattle, Washington. He has recently designed foundations for a twenty story building and has been doing extensive work in concrete for the C., M. and St. P. Ry. Co., with whom he was formerly employed.

Miss Melitta Kuhlmey, of Chicago, and Mr. W. B. Uhlein, '04, of Milwaukee, were united in marriage, May 16, at Chicago.

Mr. O. O. Wagley, '05, has resigned his position as engineer for the Valley City Street and Interurban Railway Co., of North Dakota, and is now with the Stronberg Electric Manufacturing Co., in the capacity of chief engineer. This company is about to place on the market the new Jackson Mercury Wattmeter. After Aug. 1st, Mr. Wagley will be located at Chicago.

Mr. F. W. Lawrence, '06, has accepted a position with the A. O. Smith Automobile Parts Co., of Milwaukee. He will leave the Hydraulics Department of the University in June.

Mr. F. J. Sherron, '05, who is in the employ of the American Tin Plate Co., has been transferred from Elwood, Ind., to Pittsburg, where he will act as Assistant Purchasing Agent for the company.

Mr. R. A. Sanborn, '01, is on the engineering staff serving under the direction of B. J. Arnold, on the rehabilitation of the Chicago Street Railway system.

Mr. L. R. Clausen, '97, Signal Engineer of the C., M. and St. P. Ry., has recently been elected Vice-President of the Railway Signal Association.

Mr. C. E. Abbott, '01, is Chief Engineer of Iron Mines and Quarries of the T. C. & I. R. R. Co. and the R. I. & S. Co., at Bessemer, Alabama.

Mr. H. C. Schneider, '98, has resigned his position with the Baker Mfg. Co., Evansville, Wis., to accept a position as Superintendent for the Axtell–McKee Co., Fort Worth, Texas.

Mr. H. MacMillan, '05, is now with the Fairbanks–Morse Co., Gas Engine Department, Beloit, Wis.

Mr. B. E. Tilton, ex-'97, has charge of the operations of the Pennsylvania R. R. Co., at Cleveland, Ohio.

Mr. C. D. Purple, who is in charge of large mining operations of the U. S. Steel Corporation at Mesaba Range, paid a brief visit to Madison and reports that graduates from Wisconsin have no trouble in competing with graduates from Mining Schools.

Mr. C. M. Larson, '05, is now Assistant Engineer, State Board of Assessment, and is located at the University of Wisconsin.

Mr. O. M. Jorstad, '05, is with the Westinghouse company, engaged in the electrification of the St. Clair tunnel, Port Huron, Michigan. This work is being done to remove the danger of train crews being overcome by locomotive fumes while going through the tunnel.

Mr. Arthur C. Olson, '02, who has been serving as a member of the staff engaged in the valuation of the street railway in Milwaukee, has accepted a position with the Street Ry. Co. of Scranton, Pa. He will be engaged on the reconstruction of that property.

Mr. E. A. Moritz, '04, has resigned from the employ of the C. M. & St. P. Ry., Bridge Dept., and accepted a position with the United States Reclamation Service. He is located at Zillah, Washington.

Mr. E. P. Ericksen, '90, is Engineer in charge of a Field Party on Hydrographic Work for the Chicago Sanitary District.

Mr. David L. Fairchild, '90, who has extensive mining interests on the Mesaba Range, recently made a brief visit to his mother in Madison.

Mr. S. W. Olson, '99, has been promoted to the position of Superintendent of the Ohio Brass Co., at Mansfield, Ohio.

Mr. J. T. Richards, class of 1895, is a Consulting Engineer at Edison Park, Ill. He is now in charge of the construction of a large warehouse for Montgomery Ward & Company, which will require about 70,000 yards of concrete.

Mr. Arthur Maldaner, class of 1896, is a member of the firm of Maldaner & Riddle, Consulting Engineers, First National Bank Bldg., Chicago.

Max W. King, B. S. C. E., '05, who was Resident Engineer for the Empire Engineering Co., on the Erie Canal at Port Byron, New York, has been promoted to the position of Superintendent and Engineer on Contract No. 1, for the same company, at Port Edward, New York, on the Champlain Canal.

H. A. Parker, ex-'06, who was with the Cincinnati Water Works Commission, has taken the position of Resident Engineer at Port Byron, left vacant by King.

R. G. Walter, B. S. C. E., '05, is now designing for Daniel W. Mead, Consulting Engineer, Madison, Wisconsin.

A. L. Moser, B. S. C. E., '06, has resigned his position with the C. B. & Q. Bridge Department, and accepted a position with the Michigan Central at Detroit, Michigan, on the new Detroit river tunnel building for the New York Central lines.

F. M. Johnson, B. S. C. E., '06, has left the St. Paul coast extension work and gone to the Philippines to accept a position on the government railway work.

W. A. Van Hook, B. S. C. E., '06, is now with the C. M. & St. P. Ry. on its coast extension work.

R. F. Ewald, B. S. C. E., '05, has accepted an appointment as assistant engineer on the Lower Yellowstone project of the U. S. R. S. at Glendive, Montana.

SENIOR ENGINEERS.

To facilitate the work of the Alumni Editor in arranging the Alumni directory for next year, we would request each Senior Engineer to send to the Alumni Editor the name and address of the firm with which he obtains employment, and the class of work which he is to do. This information may be sent to the Alumni Editor direct, or may be dropped into THE WISCONSIN ENGINEER mail box in the Engineering Building. Please attend to this matter before leaving Madison, if possible.

BOOK REVIEWS.

Locomotive Engines—Breakdowns and How to Repair Them. By W. G. Wallace, Past Pres't Traveling Engineers' Association. Frederick J. Drake & Co., Chicago. Flexible leather; $4\frac{1}{2}$x7 in. Numerous text illustrations and tables.

This book is intended primarily for engine drivers, and deals largely with breakdowns that are likely to occur on the road. It treats of almost every conceivable breakdown, and tells how to make the best temporary repair in order to bring the locomotive safely back to the shops. It is almost entirely of a practical nature, and in the few cases where it is necessary to treat of a theoretical subject this is done in the simplest and plainest terms, making the book easily understood by anyone who is familiar with the names of the different parts of a locomotive. While the book treats mostly of repairs, it also devotes some space to the proper care and handling of the locomotive.

The subject-matter is arranged in the form of questions and answers, which were taken largely from the Question Department of the *Brotherhood of Firemen's Magazine*, and gives the knotty questions which have puzzled engine drivers. The questions and answers are not arranged in any particular order, but they are numbered, and a complete index with cross references makes it easy to find information on any given subject. Perhaps a better arrangement would have been secured by placing all the questions on a given subject together and arranging the book into chapters.

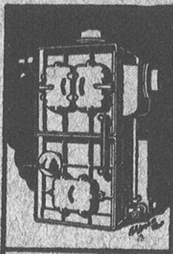
There is considerable repetition on some of the subjects, especially on the valve mechanism and the repairing of broken driving wheels.

A couple of large line drawings of locomotives are furnished in the form of folders, the different parts being numbered and named.

A number of good illustrations are scattered through the book, which aid in explaining some of the answers. Several tables, together with a lot of condensed information of a useful character, are given at the end of the book.

The book will be very useful to engine drivers, and to firemen who are preparing to take an examination for the position of engine driver. It is nicely bound in flexible leather, and is of such a size that it can be carried in the pocket.

Mr. Wallace's large experience in practical railroad work stamps the information given in his book with the reliability which a book of this character should have.



COCHRANE HEATER

$100 for the Best Theses

We shall distribute $100 in prizes

of $50.00, $25.00, $15.00, and $10.00 for the best four theses prepared by '07 graduates embodying designs of new steam plants, or complete descriptions of tests of existing plants, with suggestions for improving the methods of handling steam or water therein.

These theses are to be submitted to us before July 1, '07, and are to be duplicates of the copies turned in to the faculty. In passing upon their merit we shall give importance to the following features:

1. Good judgment in the selection and arrangement of apparatus for the conditions involved.
2. Accuracy and thoroughness in predetermining quantities and proportioning apparatus.
3. Effectiveness and lucidity in discussing the proposition, stating the reasons for choice, etc.

This competition is open to all 1907 graduates in all technical schools in the United States. The winners of this contest will be announced in POWER for September, '07.

Cochrane Open Feed Water Heaters save heat and water from exhaust steam for boiler feeding, or for use in street railways, paper mills, textile mills, locomotive shops, laundries, brewries, etc.

Cochrane Steam and Oil Separators remove water from steam going to engines or pumps, and oil from exhaust steam, so that the latter may be used safely in heating coils and rolls, for heating and ventilating, and for other industrial purposes.

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Send for our literature discussing at length the engineering questions involved in the use of our several appliances, and remember that we are always on the lookout for good men. Give your summer address.

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