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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

WATER DISTRIBUTION SYSTEM, OTTAWA

METHODS OF CONSTRUCTION USED IN CONNECTION WITH THE CAPITOL'S WATER SYSTEM—SOME DETAILS OF COST.

By L. McLAREN HUNTER,
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IN 1913 a report was prepared by Messrs. R. S. and W. S. Lea, consulting engineers, Montreal, on the improvement of the water distribution system in the city of Ottawa. Since that year work has been proceeding on the day labor system, until the present date, when proposal No. 1 has been nearly completed at a cost of approximately $420,000.

In the September 10th, 1914, issue of *The Canadian Engineer* Messrs. Leas' report was dealt with at some length.

The consulting engineer's report compared Ottawa mains with those of Worcester, Springfield, Lynn, Cambridge and New Bedford, these cities being selected at random out of a class of about the same population as Ottawa. The Ottawa system compared very unfavorably with the five systems referred to, having a much smaller percentage of the large mains—also the smaller mains are mostly 5-inch, while in the other cities 6-inch has been adopted.

The new system of mains has been laid out so as not to conflict with the existing pavements in Ottawa, and provides for a 36-inch main feeder from the point of supply on Wellington Street (replacing one or both of the present 15-inch pipes on Commissioner Street), running along Bronson to Gloucester, and thence across the city on Gloucester, crossing the canal in two lines of 24-inch pipe at Laurier Avenue. The pipe will connect with the existing mains on Lyon Street and O'Connor Street, with a new 16-inch main along Elgin and Lisgar, and thence down Cartier Street. The Lyon Street main will be extended by an 18-inch line crossing the canal by the Bank Street Bridge and following along Bank Street to Billings Bridge. The present mains on Bronson Avenue and O'Connor Street are extended as shown, and cross connecting mains are also provided on Fourth Avenue and Woodlawn Place. The canal will be crossed by a 16-inch main from the end of Cartier Street to Cedar Street by an 18-inch one from opposite Third Avenue to Sterridge Street and by 18-inch pipes at Bank Street and Bronson Avenue. The section lying between the canal and Rideau River and between Bank Street and Hurdman Road is not completely subdivided. The consulting engineer, however, assumed a street layout in order to show approximately how this district should be taken care of.

Fig. 1.—Type of Three-way Hydrant used in New Distribution System.

The four parallel mains on Bronson, Lyon, O'Connor and Cartier are extended to the principal distributor for Wellington, Central and Capital Wards, and eventually for the section across the Rideau River.

The Gloucester 36-inch main, besides supplying the Lyon, O'Connor and Cartier mains, is the principal feeder for St. George, By, Ottawa and Rideau Wards, also for Rockcliffe. After crossing the canal the Gloucester Street line divides at Nicholas Street into two branches, a 24-inch running down Nicholas to Gladstone. The other branch will be a 30-inch across Waller to Besserer, having two 16-inch connections to the Rideau Street main.

For the western part of the city a 30-inch main feeder will be constructed. This is to supply Dalhousie and Victoria Wards. Branches of 24, 20 and 16-inch will be taken off the 30-inch main.

With these mains constructed it will give a pressure of 80 lbs. for fire purposes.

Fig. No. 1 shows the style of three-way hydrants to be used throughout the city on new distribution mains. These are manufactured by Thos. Lawson and Sons, Ottawa.

In the construction of the 36-inch main on Gloucester Street the cast-iron pipes had an average weight of 6,500 lbs. and cost $38 per ton, or $10.31 per lin. ft.

The amount of lead used was 120 lbs. per joint, which cost approximately $10.

The trench was dug in loam, clay and hardpan, and as there was a sewer two feet from the trench this necessitated shoring, the method employed in doing this being shown in Fig. 2. The stringers were placed 3 ft. 6 in. apart, and were of 3-inch by 10-inch lumber. The sheeting used was 2-inch by 10-inch. These planks were strengthened by cross pieces every 6 ft. of 3-inch by 10-inch material.

The amount of lumber used per hundred feet of shoring was 1,925 lin. ft. 3-inch plank and 1,250 lin. ft.

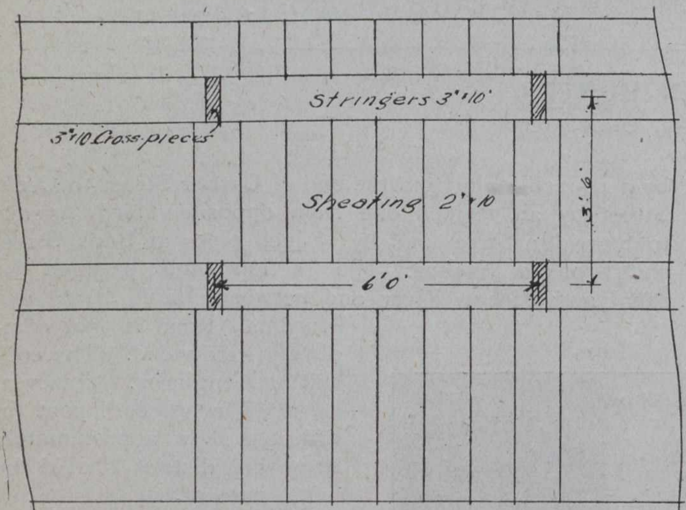

Fig. 2.—Longitudinal Section Showing Method of Shoring Trench.

2-inch plank. The greatest length of trench open at one time was 1,500 feet.

The 36-inch pipes were lowered as shown in photograph (Fig. 4). A traveller was erected running on two 4-inch trails, the pipe being lowered from the traveller by chain bocks supplied by the Herbert Morris Crane and Hoist Co., Toronto.

The joints were caulked as shown in Fig. 3. Hemp rope, "teased out," was packed as shown, and then lead was run into the joint. This was caulked with pneumatic hammers, run off a gasoline driver air-compressor (shown in Fig. 5). The average pressure at compressor

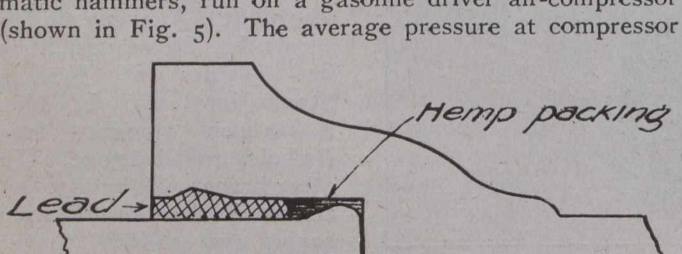

Fig. 3.—Detail of Pipe Joint.

was about 70 lbs. per square inch. Two to four hammers were run off this. Four men were kept constantly busy caulking on this main. Two men received $2.75 and two $3 per day. The engineer on the compressor was paid $3.30 per day.

The pipe-laying gang was made up of twelve men and a foreman, and the two excavating gangs had 40 men each, also a cart and from six to twelve teams.

The rates of pay for these gangs were: Foreman, $3.85; team, $5.30; cart, $2.70; watchman, $1.68; laborers, $2.52 for a nine-hour day.

The Gloucester Street main has been under construction for seventy-three days; 4.271 lin. ft. of pipe has been

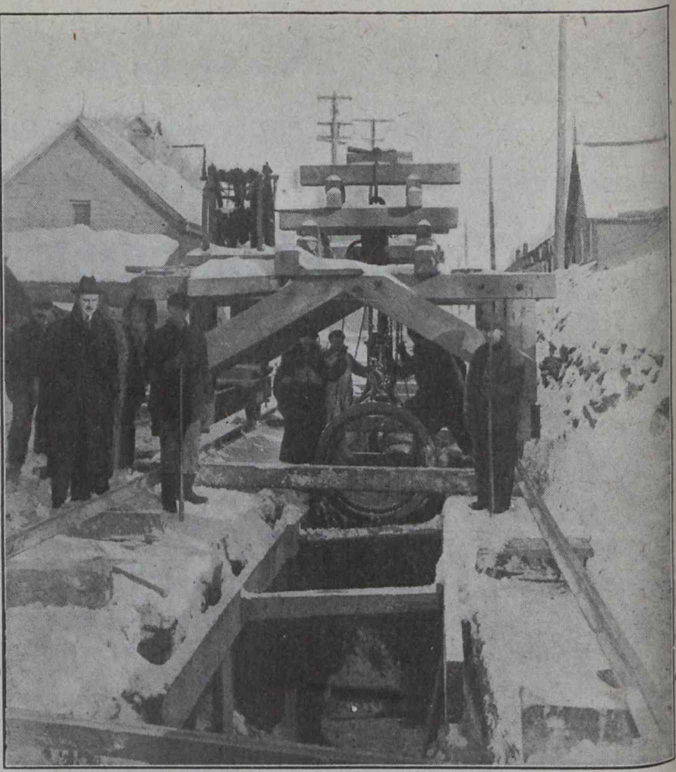

Fig. 4.—Showing 36-in. Water Main, Gloucester Street.

laid at a labor cost of $16,092.74; this includes excavating, filling, pipe-laying, shoring and pumping.

The cost per lin. ft. for labor only before frost set in was as follows:—

Excavating	$1.23
Shoring	.11
Pipe-laying	.57
Backfilling	.58
Removing earth	.38
Sundries	.20
	$3.07

After frost set in this cost increased to $3.76 per lin. ft. The pipes were supplied by the National Iron Works, Toronto.

The project has been carried out under the constant supervision of Andrew F. Macallum, commissioner of works, and W. E. MacDonald, resident engineer on the work.

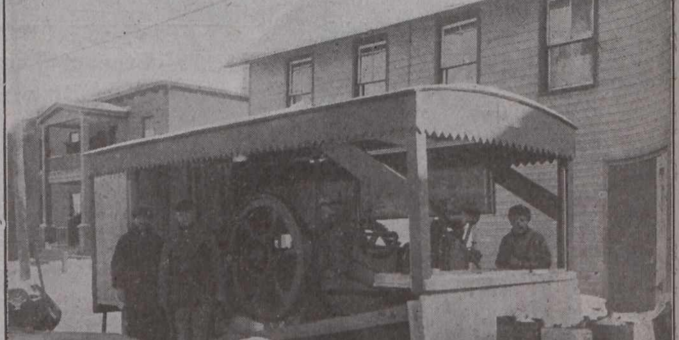

Fig. 5.—Gasoline-Driven Air-Compressor.

LIMITATIONS OF FIELD AND LABORATORY WORK IN HIGHWAY ENGINEERING IN CIVIL ENGINEERING CURRICULA.*

By C. S. Farnham,
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FIELD and laboratory courses in selected branches of applied science occupy an established position in the curriculum of every fully equipped school of civil engineering. They constitute a recognized channel through which instruction and training in civil engineering is conducted. No defence is necessary for the inclusion of field and laboratory courses in so practical a subject. It is pertinent, however, to consider whether some limitations may not exist in field and laboratory courses which render them less effective in broad civil engineering training and more particularly in that recent application of civil engineering known as highway engineering.

The educational value of field courses in surveying as well as the practical value is sometimes limited by unnecessary repetition. Several weeks may be spent in carrying on a survey in which the same methods are continually employed, or each student in a party may occupy the same position and go through the same operations for whole days at a time. This practice is sometimes defended on the ground that students thereby become skilful in surveying and consequently prove more valuable to their employers immediately after graduation, and on this account secure a firmer hold in the early stages of their professional life. The object of any educational process should be to develop the student's intellectual power and not primarily to make him skillful. Skill can be rapidly acquired after entering professional work but principles and methods can best be learned in college. The student's lack of skill in field work or in laboratory work is therefore a justifiable limitation.

Limitations upon field courses in surveying arise from the conditions of available time and place for conducting the work. The former custom of conducting field work upon the college campus during selected afternoons in term time has largely given place to continuous work for several weeks during the summer vacation at a camp maintained for the purpose. Advantages resulting are increased amount of work accomplished, freedom from interruptions which divert the student's attention from his work, more suitable ground for the conduct of certain kinds of work and the closer relations between students and instructors.

The suggestion is sometimes offered that special instruction in highway surveying should be given in a manner similar to that ordinarily followed for railroad surveying, or that less time be devoted to railroad surveying and a portion of the available time be devoted to a number of field exercises illustrating the particular kind of surveying which is employed in staking out a highway.

In railroad surveying courses to which more than ten or twelve days are devoted exclusively to the details connected with the location of a line of railroad it would appear that some repetition of work must occur and that part of the time could be employed to better advantage upon some other kind of work such as the survey of a short piece of highway. On the other hand, since the differences between the two kinds of surveying are those of detail and not of principle, it would seem unwise in view of the short time which some colleges give to railroad work to omit any essential operations connected with the location of a line of railroad for the sake of adding a few exercises in highway surveying. The engineering graduate who undertakes highway work usually enters the lower ranks of the organization of a highway department where opportunity is afforded him to learn the details of surveying through routine work.

Undergraduate laboratory courses in applied science in civil engineering include tests of materials used in construction, especially tension, compression and shear tests of steel and wood. Tests of simple structural joints, although less common, are sometimes made. Tests of masonry materials include the usual standard tests of cement with limited attention to fine and coarse aggregates and their proportioning in concrete. In view of the present standard quality of Portland cement certain tests formerly considered essential may well be omitted, thus allowing time for more careful examination of fine and coarse aggregates which engineers agree should often receive closer attention than the cement itself. Standards committees of the engineering societies perform a real service for educational as well as commercial testing laboratories by omitting unnecessary and non-essential tests which absorb the student's time and limit to that extent the effectiveness of his laboratory work.

The testing of concrete beams and slabs and waterproofing devices, together with detailed studies in proportioning, are valuable and important for the civil engineer preparing for highway work. Laboratory investigations of this character must be reserved for graduate study. Limitations which prevent their inclusion in undergraduate curricula are not so much insufficient appreciation of their value or meagre equipment as the lack of sufficient time available within the compass of a properly balanced undergraduate course.

Laboratory work in hydraulics is included in civil engineering curricula as generally as any course in experimental engineering. Field exercises in stream gauging not infrequently supplement the work of the laboratory. The usual undergraduate course in experimental hydraulics appears adequate for the purpose of the highway engineer.

The growing application of electricity to all fields of engineering is generally recognized and the inclusion of laboratory work in electricity in the curriculum for civil engineers is a logical development. Certain events have lately shown, if demonstration is necessary, that an engineer engaged exclusively in highway work may be called upon to supervise the maintenance of electrically operated draw bridges together with their illumination. Lack of time usually prevents the introduction of laboratory work in electricity into the undergraduate curriculum but the limitation can be overcome by graduate study.

Field and laboratory courses in geological studies are less common in civil engineering curricula than the subjects already considered. It is highly desirable that practical application of geology be made through field studies of soils and rocks which the civil engineer must consider in all work connected with excavation, drainage, foundations and selection of materials both for use in roads and in other structures. If this limitation exists it may be overcome, and in some civil engineering courses is overcome, through co-operation with the department of economic geology. In any event, field exercises in geology should be in charge of an instructor with sufficient experience in civil engineering to point out how knowledge of geological conditions may be of service to the civil

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engineer in the ways already mentioned. Instruction in a subject so vital to the civil engineer preparing for highway work should not be limited to textbook and classroom.

To meet the demand for men trained in special phases of highway work a few civil engineering departments have established laboratory courses for the testing of stone and brick for use in road building together with laboratory courses in the examination of bituminous materials. The value to the engineer of a knowledge of road building materials cannot be questioned, but the addition of specialized laboratory courses of this character to the undergraduate civil engineering curriculum is open to serious objections for several reasons. To make place for them, some subject of greater value must either be omitted or curtailed. A comparatively small percentage of the students in each class care to specialize in highway work. The greatest value resulting from a special course in testing lies in the student's ability to interpret the results obtained and to apply them in a practical manner to the choice of materials for definite purposes. To be able to judge of the fitness of materials upon the basis of laboratory tests requires highly specialized instruction and the expenditure of more time than a properly balanced undergraduate course can afford. Evidence is increasing that special applications of civil engineering should be reserved for graduate study when the limitations incident to undergraduate curricula can be avoided.

Modern textbooks on highway engineering devote considerable space to bituminous materials and the usual laboratory methods employed for their examination. In case the instructor in undergraduate work wishes his students to supplement their knowledge of bituminous materials by further study, the suggestion is offered that the department of industrial chemistry, if one exists, may be willing to co-operate in providing a course of lectures illustrated by apparatus and samples of materials.

In weighing the merits of laboratory courses which seem to be essential to the training of men who are to devote their energies to highway engineering, educators should not overlook the fact that studies of a different character, such as economics, accounting and the elements of business law may prove of more value in the development of future administrative officers of highway departments than a first-hand knowledge of testing materials.

In conclusion, it may be well to observe that members of this association may perform a real service by pointing out to a partially informed public the fact that our civil engineering schools are equipped to give students the fundamental training in civil engineering necessary for them to develop into capable highway engineers. Young men will avail themselves of the facilities which the schools offer as soon as positions in highway engineering are adequately compensated and the blighting limitations of residence qualifications and political influences are removed.

It is believed that the Cauvery dam, in the South of India, in the province of Mysore, when completed, will be one of the largest in the world. It will be 8,900 ft. long, and 124 ft. high. The total area covered by the lake that has been heaped up behind the dam approximates to about 43 square miles; while 17 villages have been submerged thereby, the population of which was nearly 10,000. The first stage of the reservoir, with the weir 80 ft. high, is expected to be completed by the end of the current year, the final stage being taken in hand later. It will be remembered that the original Cauvery power scheme was the first of its kind to be undertaken in India, transmitting current to the Kolar gold fields 90 miles away.

FILTER PLANT DESIGNED FOR ST. HYACINTHE.

In an article on "Water Filtration Experience," which was published in *The Canadian Engineer*, issues of December 21st and 28th, 1916, H. G. Hunter, resident engineer at Montreal for the New York Continental Jewell Filtration Co., stated that he considered it better practice to house the entire area of the filter beds. He also referred to the desirability of making pipe galleries as accessible as possible.

Mr. Hunter has forwarded two tracings which illustrate these points. These are reproduced herewith. This plant has never been built, the drawings having been made merely as a suggestion for St. Hyacinthe, P.Q. Tenders for a plant at St. Hyacinthe will probably be asked for this spring.

Mr. Hunter states in a letter to *The Canadian Engineer* that this proposed plant for St. Hyacinthe is the best example known to him "of a plant with the filters located all to one side of the pipe gallery. This design also embodies the feature that I believe desirable in this climate, of covering the entire filter and operating room with the building; it also features the straight-flow coagulating basin without baffles.

"The pipe gallery in this plant is very accessible, it being possible to travel the length of the pipe gallery without interruption. The gallery also has windows which would give proper light and ventilation. The coagulated water from the coagulating basin is taken directly on to the back of the filters without being conveyed through long pipe lines or flumes, it being desirable to deliver the water to the filters with the least possible disturbance.

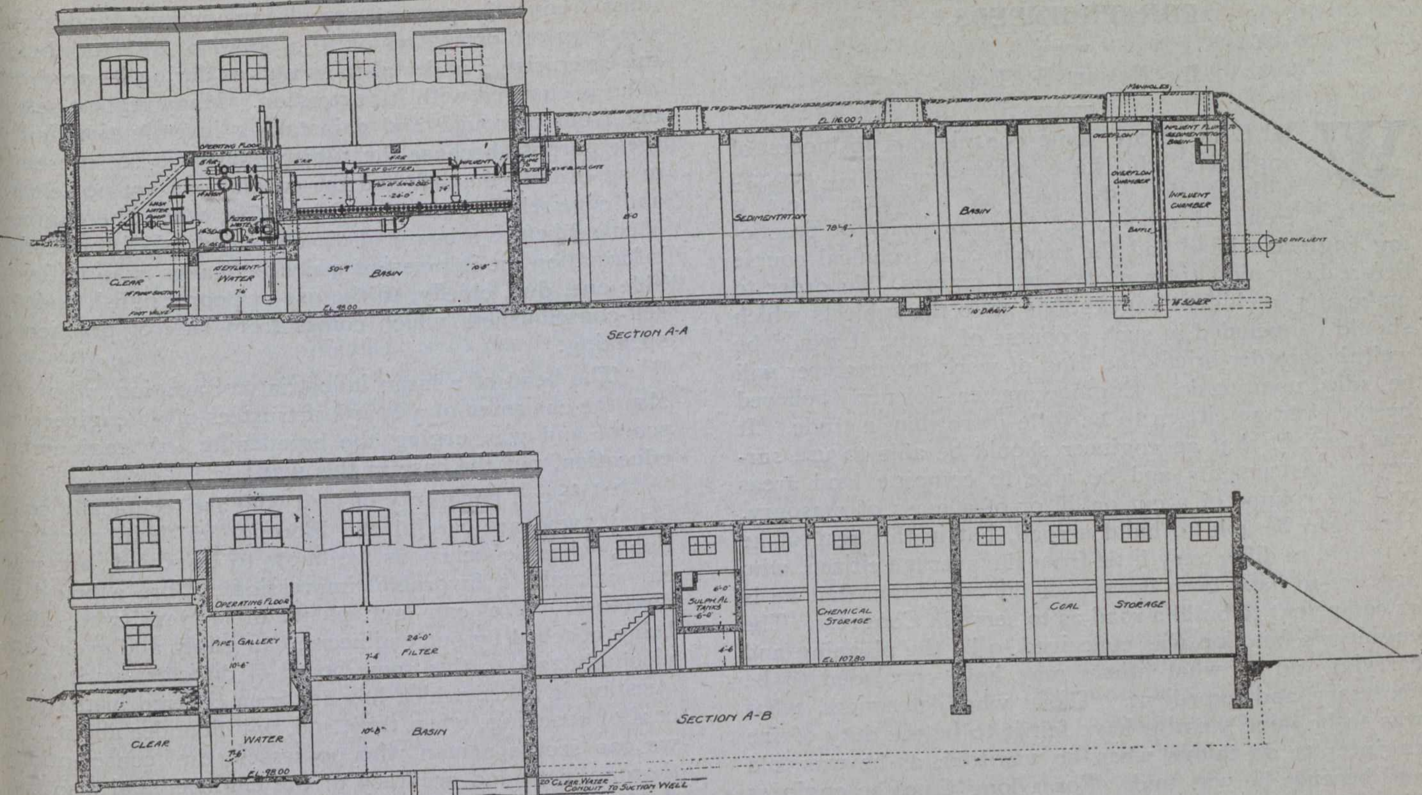
"Another point about this particular design is that it is truly a plan of a complete filtration plant; that is to say, it carries all of the accessories to a filter plant and provides space for them; notably, the wash water pump and air blower, the chemical storage room and chemical tanks. It does not provide a pumping station for low-lift pumping machinery. As stated in my paper, it is sometimes necessary to provide space for this, intending to convey the meaning that rightly the low-lift pumping station is work entirely aside from the design of a filter plant.

"In other words, all as above stated, I believe that this design for St. Hyacinthe covers all of the points mentioned in my paper as being desirable to feature in the design of a filtration plant."

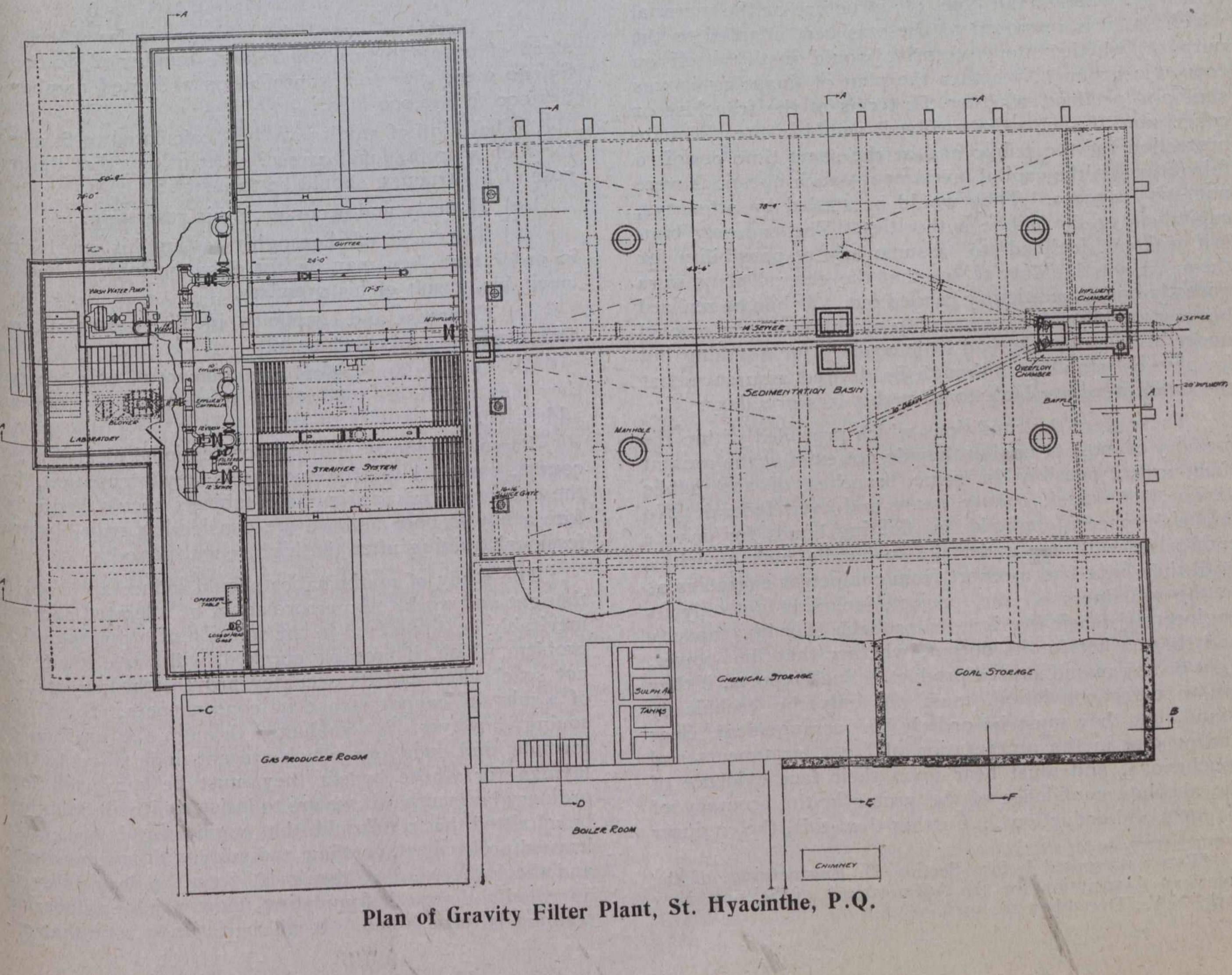
JAPANESE SHIPBUILDING.

The Japanese government is considering the question of reducing the national assistance extended to shipbuilding. The assistance hitherto given was afforded so opportunely that when the great war broke out in Europe and many ships were diverted from commercial to naval purposes by the belligerents, Japanese shipowners made great profits. The highly remunerative freight rates earned by ships have been even a greater stimulus to the growth of Japanese shipping than the government subsidies granted. This growth has, however, resulted in a heavy increase in the amount which the government is now called upon to pay shipbuilders. In 1914 these payments amounted to $815,000, in 1916 they were $1,561,000, and this year they are expected to be about $2,900,000. It is not surprising, accordingly, that the Japanese treasury is casting about for some relief.

Henry Ford, president of the Ford Motor Co., has been permitted to proceed with the construction of a $12,000,000 smelter on the Detroit River, near Detroit.



Sections Through Gravity Filter Plant, St. Hyacinthe, P.Q.



Plan of Gravity Filter Plant, St. Hyacinthe, P.Q.

VALUE OF A TRAINING IN THE HUMANITIES FOR ENGINEERS.*

By Nelson P. Lewis.

WHILE there are some conspicuous instances of engineers who have achieved marked success without the advantage of a degree from a technical school, the large majority of practicing engineers have had the benefit of a technical course before beginning their professional careers. In order to make any intelligent suggestions as to the subjects which should be included in such a course of study, it would be well to consider briefly the kind of work the engineer will be called upon to do. Engineering was formerly believed by the average citizen to be little more than a trade. It was thought that an engineer should be able to use surveying instruments and be able to compute land areas and the volume of a cut or fill or of a mass of masonry. He might be able to build a road, but in this respect he was held to differ very little from the average citizen, who appears to have been born with the conviction that he is as competent to build a road as to serve in Congress. The engineer's function was conceived to be the planning and carrying out of what others may have concluded to be necessary and expedient. Those who determined what was to be done seem to have felt it to be the duty of the engineer to do things when he was told, as he was told and because he was told. For a long time the engineer himself appeared to acquiesce in this conception of his functions. Whether or not a certain project was feasible or timely, whether the type of structure or the material which it was proposed to use was best adapted to the purpose, whether the enterprise would justify itself on economic grounds, whether the plan of financing it was sane and prudent, whether the terms of the franchise or concession, if such were involved, would insure adequate protection for the public and at the same time permit a fair return on the capital investment—such questions were not his concern. They would be settled by attorneys, capitalists or the public authorities. The engineer himself was not inclined to assume any responsibility for them; it was his duty to see that the general plans were honestly and expeditiously carried out. While he realized his responsibility for the stability of any structure erected under his direction he had little concern for anything but its physical stability, although he desired assurance that the funds were available to cover his fees or salary.

These were the conditions which prevailed within the memory of most of us, but they do not exist at the present time, except possibly in some branches of the public service, municipal, county, state and even federal. No financial concern engaged in floating bonds for private enterprises will now undertake to handle such securities until they have had a report from competent engineers as to the soundness of the project, including not only its engineering feasibility but its probable earning capacity and the market for its output, whether that be power, light or any manufactured product. Such reports, if they are to carry conviction, must not only be technically sound, but they must be orderly in arrangement, clear and concise in the presentation of facts, arguments and conclusions, and must bear upon their face evidence of the absolute confidence of the writer in the accuracy of his facts and deductions. Further than this, the engineer must frequently present verbal explanations and arguments to the promoters or to a board of directors before the enterprise is undertaken as well as during its progress, if he is charged with its execution. Many reports resulting from thorough and painstaking investigation fail of their purpose because the subject matter is not presented in an orderly manner and the conclusions are not clearly and concisely expressed. Often, too, when the engineer is called before a board of directors and asked for further information the impression which he makes is an unfavorable one, due, chiefly, to the use of poor English and the self-consciousness which comes from lack of practice in speaking.

The head of a large industrial corporation, who was also the chairman of a board of trustees of an engineering school and was urging the broadening of engineering education, put the case in this way:

"We can get plenty of men who are technically competent, who are careful and thorough in their investigations, whose conclusions we know to be sound, but who cannot make a favorable impression before a board of directors. We can get plenty of lawyers, who, after being coached by our engineers, can glibly and even convincingly talk to this same board of directors until some question is asked which has not been covered in the process of coaching, when they, too, will flounder about. If we can secure a man who possesses the conscientious thoroughness and accuracy of the engineer and also has the facility of expression and persuasiveness of the lawyer, what is a salary of $25,000 or $30,000 to us for such a man?"

He, therefore, urged that this particular school, instead of trying to turn out a large number of $2,000 to $5,000 men, give to the profession a limited number of $25,000 to $30,000 men.

What kind of studies are best calculated to fit a man for such a professional career? Let us say that the purpose of his training should be to insure:

(*a*) Honesty and accuracy in his reasoning.

(*b*) The habit of thoroughly testing his conclusions in order that they may be not only the logical, but the inevitable, result of his premises.

(*c*) Clearness and simplicity in his presentation of both premises and conclusion.

(*d*) Orderly and logical arrangement of both, so that they may readily be followed by those to whom they are addressed.

Personal honesty and high professional ideals are, of course, essential to true success in any occupation, but the course of training in these subjects should begin before a boy is born and we are considering only his professional training after the high school period.

The study of mathematics should induce accuracy in thought and work. An error cannot be tolerated and will inevitably be discovered in the solution of a mathematical problem which, if properly checked, will prove itself. If not so checked and its accuracy proven, the perpetrator of a mistake cannot escape its consequences. Such reasoning, however, is conducted through the medium of formulæ and equations which are not understood by the layman for whose benefit they must be converted into ordinary language. If we are to insist, as it will doubtless be admitted that we should, that engineering is one of the learned professions, ranking in dignity with law, medicine and theology, we may also insist upon the desirability of an equally thorough foundation upon which engineering training is to be based. It will be futile to urge that en-

*Paper presented before Section D, Engineering, of the American Association for the Advancement of Science, New York, N.Y., December 28, 1916.

gineering degrees should be given only as the result of a post-graduate course open exclusively to those presenting arts degrees. While the increasing number of men holding such degrees who come to our best engineering schools is most encouraging, it will be unwise to insist upon this as an entrance requirement. To do so would exclude many earnest young men who possess the natural ability, ambition and industry to achieve success in whatever they undertake, but who have neither the means nor the time for both the arts and engineering courses. What we may properly insist upon is that the courses in our engineering schools be liberalized by the introduction of some culture studies. Dr. J. A. L. Waddell, who has been insistent in urging the broadening of engineering education, said in an address to the Engineers' Society of Western Pennsylvania:

"Technical teachers are beginning to awaken to an appreciation of the fact that it has become absolutely essential to instruct their students in other lines than mathematics and technics in order properly to fit them for their life's work and that American engineering courses will have to be broadened so as to provide thorough instruction in economics, history, oratory, logic, business and other studies of a non-technical nature. Without a good grounding in such lines the engineer of the future will continue to be a narrow technist—unappreciated by the community and insufficiently compensated for his labors."

I am not taking too literally the subject assigned to me and insisting upon a study of "the humanities." The term is an old one and its meaning is not quite clear. The Century Dictionary defines the humanities as "including learning or literature of a merely human or secular kind as opposed to divinity, and generally the several branches of such literatures as philology, grammar, rhetoric, poetry, the study of the ancient classics and the like." Professor G. P. Marsh notes that the conviction of the value of these studies as a moral and intellectual discipline has led scholars almost universally to ascribe the origin of this appellation to a sense of their refining, elevating and humanizing influence. He expresses the belief, however, that it is an erroneous etymology, holding that they were so called in distinction from divinity, the two studies of philology and theology then completing the circle of scholastic knowledge which at the period of the introduction of the phrase scarcely included any branch of physical science. May I not then take sufficient liberty with my subject to insist that engineering courses must be enriched by the introduction of culture studies?

It is quite probable that familiarity with the classics, supplemented by a thorough course in one's own language, will greatly enrich one's vocabulary, but all of this is not needed to enable an engineer to write an intelligent report or to address a board of directors. It is not necessary that a report dealing with an engineering subject should be expressed in the language of a Howells or a James, nor will its force and that of its conclusions be lessened by the occasional use of a split infinitive or through the employment of a phrase that might give pain to some purists. It will, however, be much more forceful if expressed in simple but virile language, the habitual use of which can be acquired only by the reading of the best literature.

Many of the so-called colleges of liberal arts no longer insist upon Greek and require little Latin on the part of candidates for admission, while Latin is not carried beyond the freshman year except as an elective, although the enforcement of the group system, with one major subject and carefully balanced electives, is calculated to produce a well-educated man, if not a scholar in the old sense. Why should not our engineering schools so modify their curricula as to insist upon a major group of engineering subjects, supplemented by a thorough course in the English language and literature, a good training in, not a smattering of, one other modern language, and courses in history, economics and the law of contracts? But the technical school men will say, we would not have time to do this unless we shorten or omit some of the courses which we believe to be essential to an engineering education or add another year to our course. Then let them adopt one or the other of these alternatives, and it is quite probable that the records of their graduates would reflect greater credit upon these schools than they have in the past. A number of specific instances could be given of men whose professional training has been along entirely different lines and who have attained conspicuous success as engineers. While these cases may be exceptional, they are sufficiently numerous to justify a reference to them and even to support the plea for liberalizing engineering training.

The six-year course leading to both the arts and engineering degrees which has been adopted by a number of our universities is most encouraging evidence that engineering is coming to be considered one of the learned professions, and yet for those who can afford the time and money the ideal plan would be to pursue their culture studies in one of the smaller colleges which have not yet gone to an extreme in the adoption of the elective system. A young man will be more likely to attain real culture in such an institution, his interests will be broadened, his life friendships will be among men of various professions and occupations and he will have a better opportunity to find himself and make a wise choice of a profession if that choice may be deferred until the latter half of his college course. The influences and associations of the college campus are distinctly humanizing and, even though he may attach as much importance to athletics as to scholarship, he will have laid an admirable foundation upon which the superstructure of his professional education may be reared. The writer realizes that, while this plan may be ideal, it is beyond the reach of a great majority of those who wish to enter the engineering profession.

Next to this in its advantages may be placed the six years' course leading to the arts and engineering degrees, but even this is too long in most cases and the greatest number of engineering students will continue to begin their professional courses immediately after finishing their secondary school work.

It is unfair to these young men, it is unfair to the engineering profession, to confine their further education wholly to strictly technical courses. Extend these courses to five years, if necessary, in order to introduce the liberal studies which have been referred to, giving credit to those who present degrees from reputable colleges, so that they may complete the strictly technical work of the curriculum in four or even three years. In other words, it is time that those who are responsible for the training of engineers realized that they are fitting men for one of the learned professions and that this cannot properly be done unless the curriculum is humanized.

Eight million dollars' worth of street extensions, widenings and connections are in prospect for the West Side district of Chicago as a result of the action taken by the Chicago Plan Commission. The work will make the first unfolding of the Plan of Chicago in its aim for better traffic conditions throughout the West Side.

NITROGEN FROM SEWAGE.*

By Dr. S. Rideal, F.I.C., F.C.S.

Much progress has been made in recent years, and many of us remember the explosions which took place in some of the closed septic tanks in the early days when they were of no military importance.

These gases are derived from the anaerobic decomposition of the organic matter in the sludge, and have hitherto hardly been utilized. They consist largely of methane, and may be 2 or 3 per cent. of the volume of the sewage from which they are derived. When septic change does not take place, the equivalent organic matter remains in the sludge, and thus increases its calorific value; when formed in Imhoff or Travis tanks they are also combustible. Analyses of the gases from the Atlanta Imhoff tanks have shown 8 per cent. of hydrogen and over 80 per cent. of methane. When sludge is activated with air these gases are not formed or are lost.

Cavel, in 1912, in Paris, studied the formation of gas from the sludge. He mixed the dried sludge with 20 per cent. of coke and obtained 81.7 cubic metres of producer gas having 3,500 calories per cubic metre. In his experiments he used the gas so formed for drying fresh portions of the sludge, and calculated that from Paris and the Seine Department 300 tons of dry sludge could be obtained per day, giving 24,500 cubic metres of gas, worth 447,000 francs per annum.

To utilize these gases for war material, the Hensler engine seems best adapted for further study. In it the explosion takes place in excess of air, and the oxides of nitrogen formed, as in an arc lamp, are rapidly removed to a cooling chamber to prevent their decomposition.

When absorbed in a water tower weak nitrogen acids are produced without the employment of sulphuric acid, and thus a direct fixation of atmospheric nitrogen to nitric acid could be effected by the waste gases from our sewage works. I will not venture, from the data I have given you, to make a calculation, as in the case of glycerine, of the metric tons of nitrate that could be obtained in this way, as, fortunately, in this country at any rate, fuel for gas producers will outlast this war, but in beleaguered Bucharest, after a prolonged siege, such a device might be turned to advantage.

Utilization of Sewage Nitrogen.—I must now turn to the most important part of my subject, viz., the conversion of sewage nitrogen into available nitric acid.

The utilization of sewage nitrogen is no new problem. Sir William Crookes, many years ago, said: "We have the startling fact that in the United Kingdom we are content to hurry down our drains fixed nitrogen to the amount of no less than £16,000,000 per annum. This unspeakable waste continues, and no effective and universal method is yet contrived of converting sewage into coin." At the time of this calculation nitrate of soda was worth £7 10s. per ton, so that nitrogen even then was over £50 per ton. Mr. Ashton referred to this waste in his interesting paper on sugar from sewage in 1910 before the Manchester branch of your association. It would take me too far afield to discuss whether in war-time we ought to import nitrogen as wheat or as nitre, as the taxation of land values and the problems of transport and freights must be foreign to the business of this meeting.

I can give you some figures which show the enormity of the problem which you can better appreciate.

One hundred thousand persons produce on the average 90 grms. per person per day of fæces and 1,170 grms. of urine, equivalent to 3,300 tons per annum of solids and 43,000 tons of urine. The nitrogen in fæces is 1 per cent., in the urine .60 per cent. We have, therefore, 33 tons of organic nitrogen in the solid fæces and 258 tons in the urine.

Our military camps could furnish 11,640 tons per annum and the civil population 116,400 tons if all the nitrogen could be converted.

We may get a total nitrogen figure direct from sewage analyses. A fair figure to take is 5 parts per 100,000, or 5 lbs. per 10,000 gallons at 40 gallons per head, or 250 persons, so that a military camp of 4,000,000 could furnish 80,000 lbs., or 40 tons a day, or 14,600 tons per annum.

It is, of course, a war secret how much nitric nitrogen is required by the belligerents per annum, but we know that the Chili exports have now all been diverted from Germany, and that in the past we have relied on this source, while the Central Powers have had to improvise their raw material.

The Badische Anilin and Soda Fabrik have published their output of sulphate of ammonia by their Haber process of synthetic production from atmospheric nitrogen as equal to 300,000 tons, which is equivalent to 62,000 tons of nitrogen per annum.

This synthetic sulphate of ammonia in Germany is now being converted into nitric acid by the Ostwald process to replace the Chili nitre, which the Allies have commandeered. My figures show that in sewage we have twice as much nitrogen available, but not yet utilized, already in combination, either as ammonia or in organic form.

Recovery of Ammonia.—How can this ammonia be removed from our sewage? It is not like extracting gold from sea-water, as we have all of us smelt it at our works, and many of us have determined the amount in our laboratories.

I suggest the recovery of the free ammonia by one of two simple methods: (1) Its removal by heat; (2) its removal by air.

(1) The Removal of Ammonia from Sewage by Heat.—It is common knowledge that heat exchangers can be now designed to work with a very small loss of energy, and that the removal of the free ammonia from a tank effluent is, therefore, not an impossible task. The addition of lime to ensure the freeing of any ammonium salt may be necessary, and the effluent, after being "de-ammoniated," could be further purified by filtration or land treatment.

(2) The Removal by Air.—Sewage treatment by aeration and activation is now one of the recognized methods, and has been tried in many places in this country and America. The colloidal and suspended matters form a sludge which is especially rich in nitrogen, and the effluent contains nitrates before filtration. It would seem that the air treatment thus brings about a rapid evolution of carbonic acid and nitrification, so that the escaping gases will not, under ordinary conditions, contain any ammonia.

When, however, air is aspirated through an ordinary sewage, the ammonia is removed by the air, and I suggest that if the "activation" be carried out in presence of lime, nitrification will not be so complete and some of the ammonia will be present in the escaping gases.

*Abstract of paper read before the Association of Managers of Sewage Disposal Works.

CAUSES OF CRACKS IN CEMENT CONCRETE PAVEMENTS.*

By A. T. Goldbeck.†

It is the intent of this paper to treat merely of the causes of cracking of concrete pavements in the light of our present knowledge of the subject. There are many phases of the question of cracking that might properly be brought out in a discussion, such as the effect of cracking on the life of the road, the expense of and best methods of the maintenance of cracks, and many other allied questions. All of these, however, have been avoided and an effort has been made to treat only that phase of the subject suggested in the title.

When the internal stress in a material reaches the ultimate strength, failure ensues and manifests itself in various ways. In a brittle material like concrete, a crack indicates that the ultimate internal resisting stress, whether it is tension, compression, or shear, has been exceeded and, therefore, in order to analyze the cause of cracks in a concrete pavement, we must first discover the cause of the high internal stresses existing at rupture. This is a difficult task as the internal stresses in concrete and reinforced concrete pavements are very complex and may be caused by a number of different phenomena acting simultaneously.

A concrete road slab is attacked by many forces which slide it, in part or as a whole, along its sub-base; which bend it and warp it; which subject it to impact and shear, and may even act within its interior to exert a disrupting effect. It is little wonder that concrete roads crack, since, due to the lack of experimental data, they are constructed without sufficient knowledge of the forces to which they will be subjected.

Let the life of a slab in the road be traced from the day it is poured in order that the complexity of stresses to which it is subjected may be studied. For about ten days or two weeks after the slab is laid and while the concrete is hardening, it is the practice, for several reasons, to keep the surface thoroughly wet. In the first place, water is necessary to hydrate the more inactive particles of cement, and, moreover, it has been discovered that as long as concrete is kept wet, its length changes but very little, provided the temperature remains constant. Any slight change that does take place due to moisture is favorable to the integrity of the concrete, because moisture expands concrete, and tends to produce small compressive stresses, owing to the frictional resistance at the sub-base against this expansive movement. Should the temperature rise during this initial period, additional expansion will result with increased compressive stress in the concrete. Even this combined compressive stress, however, is seldom likely to be very large during the initial stages of hardening, and may be neglected, as the concrete is generally sufficiently strong in compression to withstand the small forces then being exerted. Should there occur a large decrease in temperature during this initial period, the concrete will contract, causing it to move with respect to its sub-base. The forces of friction thereby developed produce tension, and as green concrete is weak in tension, a decrease in temperature, when the pavement is only a few days old, may cause cracks.

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Suppose the pavement survives this initial period without mishap and is thrown open to traffic. Immediately it begins to dry out and due to this cause it starts to shrink. The friction forces at the base immediately resist this shrinkage and the result is tension in the concrete. If the tension is too great the concrete cracks where the tensile strength of the concrete has been exceeded. As the seasons of the year succeed one another, the slab is alternately wetted and dried, and in addition, subjected to a wide range of temperatures, being thus kept in constant motion over its sub-base. The forces of friction are therefore in constant action resisting this motion, and thus cause stresses, now tensile, now compressive, to exist in the concrete. Should the forces of friction be sufficiently great, the resistance of the concrete is overcome and it fails, either in tension or compression, with one of two results, the concrete is cracked, or else bulged up or crushed. Sometimes moisture and temperature aid one another, and sometimes they counteract one another, but their activities are never ended during the existence of the road. Naturally, as friction can best be developed along the length of the road, temperature changes and moisture are promotive of transverse cracks rather than longitudinal cracks.

In addition to direct compressive and tensile stresses, road slabs are subjected to bending, due to the loads of traffic and more likely to unequal settlement of the sub-base, caused by lack of homogeneity. Ununiform reaction between the slab and the sub-base due to frost may also produce cracking, the slab then being supported in some spots and not in others, thereby creating large tensile stress in bending. Frost action is more likely to cause longitudinal cracks than transverse cracks. The expanding and shrinking of the sub-base, due to varying moisture content, is also promotive of bending stresses and consequent cracking in the concrete.

In a general way, the foregoing discussion treats of some of the causes of cracking of concrete pavements, and these causes can best be classified as follows:

1. Expansion and contraction. (*a*) Change in temperature; (*b*) change in moisture content.

2. Ununiform bearing under the slab. (*a*) Frost action; (*b*) lack of homogeneity in sub-base; (*c*) moisture expansion and shrinkage of the sub-base.

3. Excessive bending stress due to heavy loads and impact.

These causes will be considered in detail so far as our present knowledge will permit.

Expansion and Contraction.—(*a*) Change in temperature: It has been well established by several investigators that concrete expands and contracts as the temperature changes, and the amount of movement equals 0.0000055 inches per inch of length. If a concrete road is built in the summer season when the temperature is 90° F. and the temperature in the following winter falls to 0° F., the concrete must contract an amount equal to $0.0000055 \times 90 = 0.00495$ inches per inch of length. This contraction could do no harm if it were not for the resistance offered by friction between the sub-base and the slab. When the concrete contracts, the friction at the base resists the contraction and the amount of tension produced in the concrete is dependent on the amount of friction acting. Friction at the base varies with the kind of base and the degree of roughness and tests recently made by the author throw some light on the amount of friction that can act at the sub-base when the slab expands and contracts.

Friction at the Sub-base.—The tests referred to above were made by sliding 2-ft. x 6-ft. x 6-in. concrete slabs along previously prepared sub-bases. The sliding force was applied by means of a long lever and the magnitude of the force was measured with a carefully calibrated dynamometer. The amount of movement of the slab was read with a Berry strain gauge while the load increased slowly and steadily.

As the load was applied, the slabs seemed to move very slightly, even at the first application, except where a sub-base of large broken stone was used. In this instance a high load was necessary to start the slab in motion after which it required no more load than some of the other bases. Apparently there does not exist a constant value for the coefficient of friction, for the greater the displacement the greater the force of friction becomes.

The values of the frictional resistance offered at various displacements are given in the table at the foot of page.

When the slab on the loam base had been slid 0.035 inch, the then existing load of 1,600 pounds was released to zero, and the slab recovered 0.017 inch of its motion. From this recovery behavior it is seen that the sub-base acts in a somewhat elastic manner, and some of the resistance offered to the expansion and contraction of the slab must be that necessary to deform the sub-base. The material of the sub-base is far from being perfectly elastic and it must therefore gradually yield under a slowly applied load such as would obtain in the expansion and contraction of concrete pavements. Hence it is not at all reasonable to assume that the maximum friction shown in the tests described actually exists in concrete pavements, even where their movement is large. The above tests were made in periods of about 10 minutes each, while the corresponding movements in the road might take days.

Moisture Shrinkage.—When a specimen of concrete is permitted to harden under continually moist conditions, it expands slightly; on the other hand shrinkage takes place when it hardens in a dry atmosphere. The amounts of expansion and contraction are dependent to some extent on the richness of the mixture and also on the thoroughness of the drying. For instance, consider the experiments on two specimens, 1 : 2 : 4 and 1 : 3 : 6 concrete, of very wet and very dry consistency. Several days after hardening they were immersed in water and extensometer readings were made on them at frequent intervals. As long as they were wet they remained expanded, with the maximum expansion of 0.0001 inch per inch of length. After 6 months they were removed from the water and allowed to dry out in the warm dry air of the laboratory, when they immediately began to contract, reaching an ultimate contraction of 0.0008 inch per inch of length. It must be emphasized, however, that these specimens became exceedingly dry in a very short time after their removal to the air of the laboratory and probably very much dryer than they could ever become in the road. When specimens are subjected to the every-day wet and dry weather conditions, they do not change in length very much due to change in moisture content, because their moisture content does not vary greatly under such conditions. Concrete in the road may, under exceptional conditions, be made to suffer extreme drying, but it is very probable that most concrete roads absorb much water by capillarity from the damp or wet underlying sub-base, and moreover, the water that is absorbed during a period of wet weather does not completely evaporate between successive spells of wet weather. However, there is sufficient evaporation from the surface to cause some shrinkage of concrete in the road as evidenced by the formation of cracks when road slabs are allowed to dry out too quickly. The maximum amount of shrinkage that concrete can reach is 0.0008 inch per inch of length, but it is probable that, in general, the moisture shrinkage of concrete road slabs does not exceed more than 0.0004 inch.

Combined Moisture and Temperature Changes.—It is evident, therefore, that both moisture and temperature act to cause creeping of the slab in the road, and it must be realized that the relative magnitude of these two effects depends on the range of temperature, on the rainfall, and on the drainage of the sub-base. In an exceptionally well-drained sub-base and in a dry climate, the moisture shrinkage of the concrete will be large, and will add to the contraction due to changes of temperature. This shrinkage may amount to 0.0004 inch per inch of length and if there is a decrease in temperature of 100° F. there will be an additional shrinkage of $100 \times 0.0000055 = 0.00055$ inch or a total shrinkage of 0.00095, or, roughly, 0.001 inch for each inch of length. On the other hand there may be much moisture in the sub-base which will keep the concrete expanded 0.0001 and the net shrinkage will then equal 0.00055 minus 0.0001 or only 0.00045 inch.

It has been pointed out that the sliding of concrete along the sub-base develops frictional resistance of considerable magnitude, and when the tension developed in the concrete due to the forces of friction exceeds the tensile strength of the concrete a crack must form. Let the coefficient of friction be equal to 1.0, and assume the tensile strength of the concrete to be 150 pounds per square inch. Let L equal the distance between cracks, then, in a slab 12 inches wide and 6 inches thick, the stress at rupture equals 72 square inches × 150 pounds, equals 10,800 pounds. This stress must be supplied by the forces of friction acting over the distance between cracks, or $fLw = 72$ square inches × 150 pounds per square inch where w equals the weight of the concrete per linear foot. This equation reduced to $1.0 L 72 = 72 \times 150$ or $L = 150$, the distance between cracks. If $f = 2.0$, then $L = 75$

Frictional Resistance of Concrete on Various Sub-bases.

Kind of base.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.
Level clay	0.001	480	0.55	0.01	1,130	1.3	0.05	1,800	2.07
Uneven clay	0.001	500	0.57	0.01	1,120	1.29	0.05	1,800	2.07
Loam	0.001	300	0.34	0.01	1,030	1.18	0.05	1,800	2.07
Level sand	0.001	600	0.69	0.01	1,080	1.24	0.05	1,200	1.38
¾-inch gravel	0.001	450	0.52	0.01	960	1.10	0.05	1,100	1.26
¾-inch broken stone ...	0.001	380	0.44	0.01	800	0.92	0.05	950	1.09
3-inch broken stone	0.001	1,060	1.84	0.01	1,550	1.78	0.05	1,900	2.18

feet, so that the greater the friction the closer will be the spacing between cracks.

The above calculations indicate the advisability of forming the sub-base as smoothly as possible. Of course, the tensile strength of the concrete can not obtain unless the concrete is stretched sufficiently. When 150 pounds per square inch exists in the concrete, each inch is stretched 150/3,000,000 = 0.00005 inch and it has been shown that the shrinkage due to moisture and temperature change may amount to 0.00095 inch, far in excess of the amount required to cause rupture.

The foregoing considerations are based on mature concrete. When the concrete is only a few days old, the tensile strength is very small indeed, and the modulus of elasticity is likewise low. When but two days old the tensile strength may be as low as 50 pounds per square inch, and the modulus of elasticity in tension may be only 1,000,000. The stretch required to produce rupture is then 50/1,000,000 = 0.00005. This amount of shrinkage could readily be caused by slight drying out or by a decrease in temperature of only 0.00005/0.0000055 = approximately 9 degrees F. A comparatively small decrease in temperature may thus produce cracking in the concrete pavement. If the tensile strength at two days is only 50 pounds per square inch, the distance between cracks, when the concrete contracts sufficiently, will be smaller than it is if the concrete cracks at a later period when it has attained higher strength. Assuming the same values for friction and weight of concrete as before we have

$$fLw = 50 \times 72, \text{ or}$$
$$1.0 \times L \times 72 = 50 \times 72$$
$$L = 50$$

If the coefficient of friction equals 2.0. There may be times, due to a big fall in temperature just after the concrete has hardened and the tensile strength is exceedingly low, when the cracks will be much closer together than the above figures show. There are often cases when the sub-base contains projections and depressions that greatly add to the frictional resistance offered to sliding and such a sub-base aids in the production of cracks at close intervals.

Field Measurements.—In order to gain some idea of the actual changes in length which takes place in the road slab in place, many field measurements have been made by the Office of Public Roads and Rural Engineering. In general, the expansions and contractions were found to follow closely the temperature changes.

Uniform Bearing Under the Slab.—Irrespective of what may cause lack of uniformity of bearing under the slab, let it be assumed that due to some cause this unequal support exists. As an exaggerated case, let it be assumed that the slab is largely supported at its two sides, and acts therefore as a single beam. Assume a 16-foot roadway 6 inches thick. The fibre stress in the section of greatest bending moment then equals $S = \frac{Mc}{I} = \frac{WL}{8} \times \frac{6}{bd^2} = \frac{72 \times 16 \times 16 \times 12}{8} \times \frac{6}{12 \times 36} = 384$ pounds per square inch. This value is close to that of the modulus of rupture of the kind of concrete used in road construction. The dead weight of the pavement alone is thus almost sufficient to cause cracking if the slab is afforded improper support. The same condition would hold if the pavement were unsupported at the sides but fully supported at the centre. Add the weight and impact of traffic to increase the bending moment due to dead load and it will be readily seen that under the right conditions of improper sub-base support, a longitudinal crack is likely to form.

Before considering these conditions producing improper support, let the amount of deflection of the slab at rupture be figured. In a simple beam uniformly loaded, the deflection at the centre $D = \frac{5}{384} \frac{WL^3}{EI}$. Assuming a 6-inch slab, 16 feet wide and supported at its sides, the deflection under its own weight equals $\frac{5}{384} 72 \times 16 \frac{(16 \times 12)^3}{3{,}000{,}000} \times \frac{12 \times 6^3}{12} = 0.164$ inches. The slow yielding or "flow" of concrete acts to increase this figure and might even treble it, thereby making the possible deflection as much as 0.5 inch when the crack forms.

Regarding the causes of unequal bearing, nothing very definite may be said. It is generally recognized that unequal compaction of the sub-base due to lack of homogeneity and to uniform rolling may cause more settlement in some spots than in others, and many sub-bases built of old Telford or macadam roads are very likely to lack uniformity. Again, the well-known expansive effect of freezing can very readily act with different intensity in different parts of the road, thereby causing more than enough rise to produce cracking. The shrinkage of soils when they dry out and their swelling when moistened is an occurrence of every-day observation, and it is quite possible that the shrinkage of the foundation away from the concrete is sufficient in places to cause great bending stress with the formation of cracks in the concrete. The raising of the sub-base in spots need not be more than 0.2 inch to cause cracking and the expansive effect of the frost and the swelling and shrinkage effect of moisture on the sub-base may be considerably more than this. The writer now has some experiments in progress to show the effect of freezing and moisture on the vertical movement of the road.

Impact of Traffic.—The weight of traffic serves but to accentuate the stresses due to the other physical causes. Heavy loads on a thin slab or where the bearing is ununiform may cause either transverse or longitudinal cracks and when these loads are applied suddenly or with impact, as is the case with the modern heavy truck and steel-tired trailer, these loads will aid the other causes of cracking, although they may not be severe enough to be effective themselves. Traffic, however, often breaks off the corners of slabs, the load then being concentrated near a point having poor bearing.

In conclusion, it must be emphasized that great effort should be exerted to protect the concrete during its initial stages of hardening. Do not mix it any wetter than necessary to obtain smooth yet economical construction. Protect it from sudden decrease in temperature and keep it wet for at least two weeks in order to prevent undue shrinkage while the concrete is green. Much attention should be given the sub-base, for, as has been pointed out, the friction at the base causes transverse cracks. This friction may be greatly reduced by proper care in the preparation of the sub-base and in this way the cracks may be widely distributed if not entirely eliminated. In addition, provide proper drainage to keep the sub-base as dry as possible, so that the effect of frost and the settlement due to moisture may be eliminated. Finally, design the slab as to thickness to carry the loads it is supposed to carry, irrespective of whether the sub-base offers uniform bearing or not.

TEST OF A FOUR-INCH SINGLE-STAGE TURBINE PUMP.

By J. H. Parkin, University of Toronto.

ACTUAL performance data or test results of small, low-head centrifugal pumps (under 6-in. and 50 ft. head) are seldom published, and little is available for reference compared with the large amount on pumps of larger size. This condition is primarily due no doubt to monetary considerations. Large pumps have large initial and operating costs, and generally are of more or less special design to meet separate requirements. Since the quantities involved are large, a slight difference in the design or operation may mean a considerable saving, either in initial or operating cost, and carefully conducted acceptance tests are, therefore, run, the results of which later find their way into the technical press.

On the other hand, small-size pumps are of relatively small initial and operating cost and are generally manufactured in stock sizes. From curves and data supplied by the manufacturer the stock size is chosen coming nearest to requirements. The nice differences considered in the case of larger pumps do not enter into the question and acceptance tests are not often made or published. The manufacturer doubtless runs tests to determine the ratings, etc., but these are seldom made public except in such limited form as to be almost valueless. Hence the following description and results of a series of tests run on a 4-inch single-stage turbine pump may be of interest.

The test was run primarily to determine the pump characteristics and the effect of the stationary exit guide-ring on these characteristics, and as an outcome a short investigation was made of the effect of speed on the characteristics.

Description of Pump.—The pump was of the horizontal, belt-driven, single-stage type, with single 4-inch suction and 4-inch discharge, designed to operate at 1,400 r.p.m., giving 0.7 c.f.s. at 45 feet head. The general design of the pump may be seen in Fig. 1. The single 10-inch runner was of bronze, with eight vanes, all faces being finely finished and polished. The outside stationary guide-ring, also of bronze, is 14 inches, outside diameter, with seven finely polished guides. (See Fig. 2.) There is provided another stationary ring without guides, by the use of which the pump may be operated purely as a centrifugal pump. The balancing of end thrust is by the Jaeger system, with a water-cooled thrust bearing as a precautionary measure. The suction entrance is of rather peculiar form to facilitate removal of exit guide-ring and interior examination.

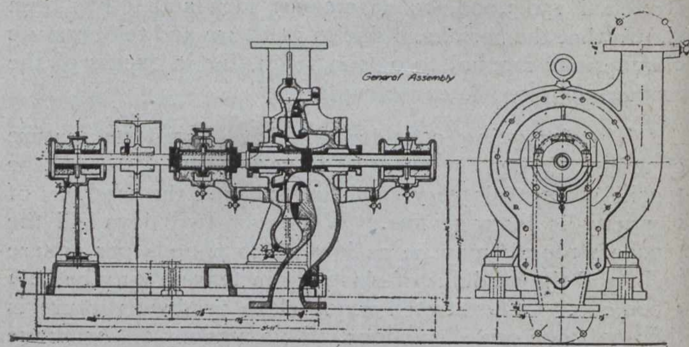


Fig. 1.

Layout of Test Apparatus.—The layout of the pump, motor, piping and various gauges for the test are shown in Fig. 3.

The pump was set up on a steel tank containing a 2-foot contracted weir. The supply was drawn from the tank on one side of the weir through a common 4-inch strainer foot valve and discharged through 4-inch W.I. pipe, a Venturi meter and gate valve into the tank on the other side of the weir, thence through a pair of wooden baffles (to remove turbulence) and over the weir.

Suction pressures were indicated by mercury suction gauge connected through a catch-cup to the suction pipe below the pump flange. The catch-cup, constructed of ordinary pipe fittings, was provided because of the danger arising when mercury is drawn into a pump. With a cup such as this between the manometer and pump the mercury is prevented from entering the pump. A similar cup was provided on the throat line of the Venturi meter. Speeds were taken by calibrated tachometer.

Table No. 1 — Test of 4 in. Single Stage Turbine Pump — Test Data — Speeds of 1000, 1100 and 1200 r.p.m.

No	Pressure Gauge	Pressure Head	Suction Gauge	Suction Head	Total Head	Venturi Gauge	Venturi Disch.	Weir Head	Weir Disch.	Mean Disch.	Pump Speed	Power Input	Power Friction	Power To Water	Power Output	Efficiency Mech.	Efficiency Hyd'c	Efficiency Net	No
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2.01	3.95	10.05	11.27	15.24	16.80	0.719	2.65	0.718	0.719	995	1420	351	1069	683	75.2	64.0	48.1	1
2	10.00	11.94	8.00	9.03	20.97	12.12	0.610	2.40	0.610	0.610	995	1372	351	1021	798	74.4	78.1	58.1	2
3	14.85	16.79	6.40	7.28	24.07	8.70	0.517	2.14	0.513	0.515	995	1317	351	966	774	73.3	80.1	58.8	3
4	19.40	21.34	5.00	5.75	27.09	5.55	0.413	1.85	0.410	0.411	1000	1248	352	896	694	71.8	77.4	55.6	4
5	21.90	23.84	4.00	4.66	28.50	3.40	0.323	1.58	0.329	0.326	1000	1057	352	705	579	66.7	82.1	54.8	5
6	22.25	24.19	3.40	4.02	28.21	2.06	0.252	1.32	0.255	0.253	1004	970	354	616	445	63.5	72.2	45.9	6
7	21.75	23.69	3.00	3.58	27.27	1.28	0.198	1.11	0.195	0.196	1004	904	354	550	334	60.8	60.7	36.9	7
8	20.22	22.16	2.60	3.14	25.30	0.56	0.131	0.81	0.120	0.125	1005	792	355	437	198	55.1	45.3	25.0	8
9																			9
10																			10
1100 R.P.M.																			
11	3.20	5.14	11.80	13.10	18.24	19.80	0.780	2.79	0.780	0.780	1093	1743	376	1367	887	78.4	64.9	50.9	11
12	13.80	15.74	8.90	10.00	25.74	15.00	0.679	2.55	0.678	0.679	1105	1705	379	1326	1088	77.1	82.1	63.8	12
13	17.96	19.90	7.20	8.06	27.96	11.34	0.590	2.35	0.591	0.591	1090	1656	375	1281	1030	77.5	80.4	62.2	13
14	21.92	23.86	6.20	6.99	30.85	8.46	0.510	2.10	0.498	0.504	1090	1575	375	1200	969	76.2	80.7	61.5	14
15	25.60	27.54	5.10	5.79	33.33	5.50	0.412	1.84	0.408	0.410	1100	1458	378	1080	851	74.1	78.8	58.4	15
16	27.80	29.74	4.10	4.70	34.40	3.60	0.333	1.60	0.333	0.333	1100	1330	378	952	714	71.6	75.0	53.7	16
17	28.10	30.04	3.40	3.94	33.98	2.38	0.270	1.34	0.260	0.265	1100	1175	378	797	561	67.9	70.4	47.8	17
18	27.50	29.44	3.00	3.51	32.95	1.16	0.189	1.09	0.191	0.190	1105	1050	379	671	396	63.9	58.9	37.7	18
19	26.32	28.26	2.60	3.06	31.32	0.56	0.131	0.83	0.127	0.129	1109	925	380	545	252	58.9	46.2	27.2	19
20	13.00	14.94	2.60	3.06	18.00	0.40	0.111	0.72	0.103	0.107	1110	922	381	541	120	58.7	22.1	13.0	20
1200 R.P.M.																			
21	5.00	6.94	12.80	14.20	21.14	—	—	2.90	0.826	0.826	1190	2117	400	1717	1089	81.1	63.5	51.4	21
22	16.00	17.94	10.40	11.57	29.51	17.60	0.735	2.69	0.735	0.735	1200	2082	403	1679	1351	80.6	80.5	64.9	22
23	21.50	23.44	8.10	9.05	32.49	12.50	0.620	2.41	0.616	0.618	1186	1987	399	1588	1252	80.0	78.8	63.0	23
24	27.20	29.14	6.24	7.04	36.18	8.50	0.511	2.13	0.510	0.511	1187	1867	399	1468	1152	78.6	78.5	61.7	24
25	31.00	32.94	4.94	5.61	38.55	5.70	0.418	1.86	0.415	0.416	1190	1735	400	1335	1000	77.0	74.9	57.6	25
26	33.60	35.54	3.90	4.48	40.02	3.75	0.339	1.61	0.337	0.338	1195	1605	401	1204	844	75.1	70.1	52.6	26
27	33.30	35.24	3.40	3.94	39.18	2.21	0.261	1.36	0.264	0.262	1195	1433	401	1032	641	72.1	62.1	44.8	27
28	31.80	33.74	2.80	3.29	37.03	1.14	0.187	1.10	0.193	0.190	1200	1282	403	879	439	68.5	49.9	34.2	28
29	30.40	32.34	2.60	3.06	35.40	0.38	0.108	0.86	0.132	0.120	1195	1109	401	708	265	63.9	37.4	23.9	29
30	13.50	15.44	2.60	3.06	18.50	0.26	0.089	0.55	0.072	0.072	1195	1072	401	671	81	62.6	12.1	7.5	30

Table No. 1.

Method of Test.—A series of tests were run on the pump for speeds from 1,000 r.p.m. up to 1,500 r.p.m., varying by increments of 100, and at each speed the discharge was varied from the maximum (valve wide open) down to the lowest at which steady operation would occur, taking the necessary readings at these two, and about eight intermediate discharges. A further test was run at normal speed (1,400), with the stationary guide-ring removed to determine the effect of the guide-ring on the pump operation.

The results are as shown in the accompanying tables and curves.

In calculating the total operating head of the pump from the readings of the pressure and suction gauges, these readings were corrected to equivalent readings at the centre of the pump and added. The velocity heads being equal may be neglected.

Table No. 2

Test of 4 in. Single Stage Turbine Pump — Test Data — Speeds of 1300, 1400 and 1500 r.p.m.

No.	Pressure Gauge	Pressure Head	Suction Gauge	Suction Head	Total Head	Venturi Gauge	Venturi Disch.	Weir Head	Weir Disch.	Mean Disch.	Pump Speed	Power Input	Power Frictn.	Power To Water	Power Output	Efficiency Mech.	Efficiency Hyd.	Efficiency Net	No.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
31	8.00	9.94	13.60	15.13	25.07	—	—	2.98	0.859	0.859	1295	2560	430	2130	1331	83.2	62.5	52.0	31
32	20.60	22.54	11.00	12.30	34.84	18.60	0.756	2.74	0.756	0.756	1300	2532	433	2099	1642	82.8	78.3	64.8	32
33	27.20	29.14	8.70	9.79	38.93	13.80	0.651	2.49	0.651	0.651	1300	2483	433	2050	1580	82.5	77.1	63.6	33
34	33.40	35.34	6.90	7.75	43.09	9.70	0.546	2.22	0.541	0.544	1300	2360	433	1927	1462	81.6	75.9	61.9	34
35	38.90	40.84	5.00	5.79	46.63	6.20	0.437	1.92	0.435	0.436	1300	2178	433	1745	1269	80.1	72.7	58.2	35
36	40.40	42.34	4.00	4.70	47.04	4.10	0.355	1.67	0.355	0.355	1300	2075	433	1642	1041	79.2	63.4	50.2	36
37	39.50	41.44	3.30	3.90	45.34	2.42	0.273	1.42	0.280	0.280	1300	1802	433	1369	780	75.9	57.0	43.2	37
38	38.00	39.94	2.80	3.36	43.30	1.19	0.191	1.11	0.195	0.195	1300	1553	433	1120	520	72.1	46.4	33.5	38
39	36.20	38.14	2.60	3.06	41.20	0.37	0.106	0.87	0.134	0.134	1300	1363	433	930	308	68.2	33.5	22.6	39
40	19.00	20.94	2.60	3.06	24.00	0.33	0.101	0.67	0.094	0.094	1295	1340	430	910	145	67.9	15.9	10.8	40
1400 R.P.M.																			
41	11.70	13.64	14.30	15.82	29.46	—	—	3.05	0.892	0.892	1400	3065	471	2594	1639	84.7	63.2	53.5	41
42	24.20	26.14	12.00	13.30	39.44	21.10	0.805	2.85	0.805	0.805	1410	3075	476	2599	1980	84.5	76.2	64.3	42
43	32.70	34.64	9.50	10.59	45.23	16.10	0.704	2.60	0.698	0.701	1410	3028	476	2552	1978	84.5	77.5	65.3	43
44	40.00	41.94	7.80	8.61	50.55	11.40	0.592	2.35	0.591	0.592	1410	2883	476	2407	1866	83.5	77.5	64.7	44
45	45.00	46.94	6.20	6.98	53.92	8.00	0.496	2.10	0.498	0.497	1410	2735	476	2259	1670	82.5	74.0	61.0	45
46	48.20	50.14	4.90	5.56	55.70	5.65	0.417	1.85	0.410	0.414	1410	2580	476	2104	1438	81.6	68.3	55.8	46
47	48.00	49.94	3.90	4.48	54.42	3.65	0.335	1.61	0.336	0.336	1410	2295	476	1819	1139	79.2	62.6	49.6	47
48	46.00	47.94	3.30	3.82	51.76	2.16	0.258	1.35	0.261	0.260	1400	1970	471	1499	839	76.1	56.0	42.6	48
49	45.00	46.94	2.90	3.37	50.31	1.34	0.203	1.10	0.190	0.196	1400	1797	471	1326	596	73.8	44.9	33.2	49
50	42.00	43.94	2.60	3.06	47.00	0.64	0.140	0.85	0.132	0.136	1400	1583	471	1112	398	70.2	35.8	25.1	50
1500 R.P.M.																			
51	14.50	16.44	15.50	17.15	33.59	—	—	3.125	0.923	0.923	1500	3720	523	3197	1932	86.0	60.5	51.9	51
52	31.00	32.94	12.10	13.26	46.10	21.10	0.805	2.85	0.805	0.805	1500	3735	523	3212	2315	86.0	72.1	62.0	52
53	42.50	44.44	9.70	10.81	55.25	15.60	0.693	2.60	0.698	0.696	1500	3550	523	3027	2400	85.3	79.2	67.6	53
54	47.80	49.74	7.60	8.50	58.24	11.50	0.594	2.35	0.591	0.593	1500	3315	523	2792	2158	84.4	77.1	65.0	54
55	52.60	54.37	6.10	6.88	61.25	8.00	0.496	2.10	0.498	0.497	1500	3185	523	2662	1898	83.6	71.2	59.6	55
56	56.50	58.27	5.10	5.79	64.06	5.80	0.422	1.87	0.416	0.419	1500	2835	523	2312	1673	81.5	72.4	59.0	56
57	54.80	56.37	4.00	4.59	61.16	3.50	0.328	1.60	0.334	0.331	1490	2550	517	2033	1262	79.7	62.1	49.5	57
58	52.60	54.37	3.30	3.82	58.19	2.16	0.258	1.35	0.261	0.260	1490	2285	517	1768	944	77.3	53.4	41.3	58
59	51.00	52.77	2.90	3.37	56.14	1.20	0.192	1.10	0.190	0.191	1500	2140	523	1617	669	75.6	41.3	31.3	59
60	45.80	47.74	2.60	3.06	50.80	0.64	0.140	0.85	0.132	0.136	1500	1955	523	1432	430	73.3	30.0	22.0	60

Table No. 2.

The discharge, as already stated, was determined by two methods, namely, Venturi meter and weir. The Venturi meter formula $Q = A\,Cd\,\sqrt{2g\,(H_1 - H_2)}$ in the case of this meter (2-inch throat and $Cd = 0.98$) reduces to $Q = .1754\,\sqrt{H}$ where H is pressure difference in inches of mercury. The Hamilton Smith weir formula $Q = \frac{2}{3}\,Cd.b.\,\sqrt{2g}\,H^{3/2}$ was used for the contracted weir and reduced to $Q = 10.69\,Cd\,H^{3/2}$ for this weir. A head discharge curve was plotted to facilitate the work (see curve sheet 1). It was found that for heads on the weir greater than two inches the velocity of approach affected the discharge and a correction was necessary, as shown.

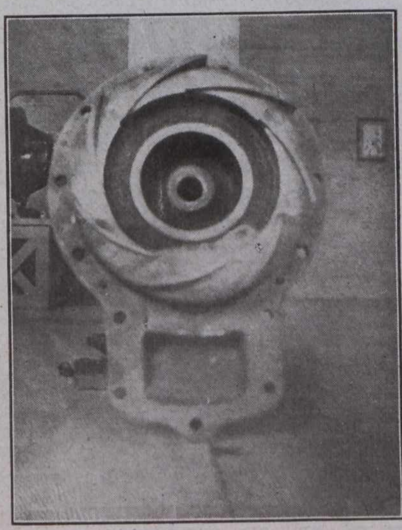


Fig. 2.

The total or net efficiency of the pump is the ratio of the output power to the power delivered to the belt. This efficiency includes the efficiency of the belt drive. It seems proper to include this latter because the pump is belt-driven, the type of drive is a part of the pump itself and the losses introduced by it must always be reckoned on. The mechanical efficiency of the pump is the ratio of the power delivered to the water, to the power input. The ratio of the net power output to the power delivered to the water is the hydraulic efficiency. The product of mechanical and hydraulic efficiencies is the total efficiency.

Results.—Tables No. 1 and No. 2 show in detail the results of the pump test.

Table No. 3 gives the principal results corrected to constant speeds.

The values of Table 3 were calculated from those of Tables 1 and 2 by making use of the following well-known fundamental relations relating to water turbines and centrifugal pumps, namely:—

1. The head varies as the square of the speed, hence $H = H_1 \left(\frac{N}{N_1}\right)^2$

2. The discharge varies as the square root of the head, hence $Q = Q_1 \sqrt{\frac{H}{H_1}}$

3. The power varies as the cube of the square root of the head, hence $P = P_1 \left(\frac{H}{H_1}\right)^{3/2}$

In the above N_1, H_1, Q_1 and P_1 are the actual test results and N, H, Q and P the corrected values.

The results were thus all reduced to a common speed and then plotted on curve sheets.

Discussion of Results.—At normal speed it was found that the pump came very close to the designed requirements, namely, 0.7 c.f.s. at 45-ft. head and 1,400 r.p.m. For discharges less than the last point plotted on curve sheet it was found that any further closing of the valve caused the discharge to drop rapidly, finally ceasing

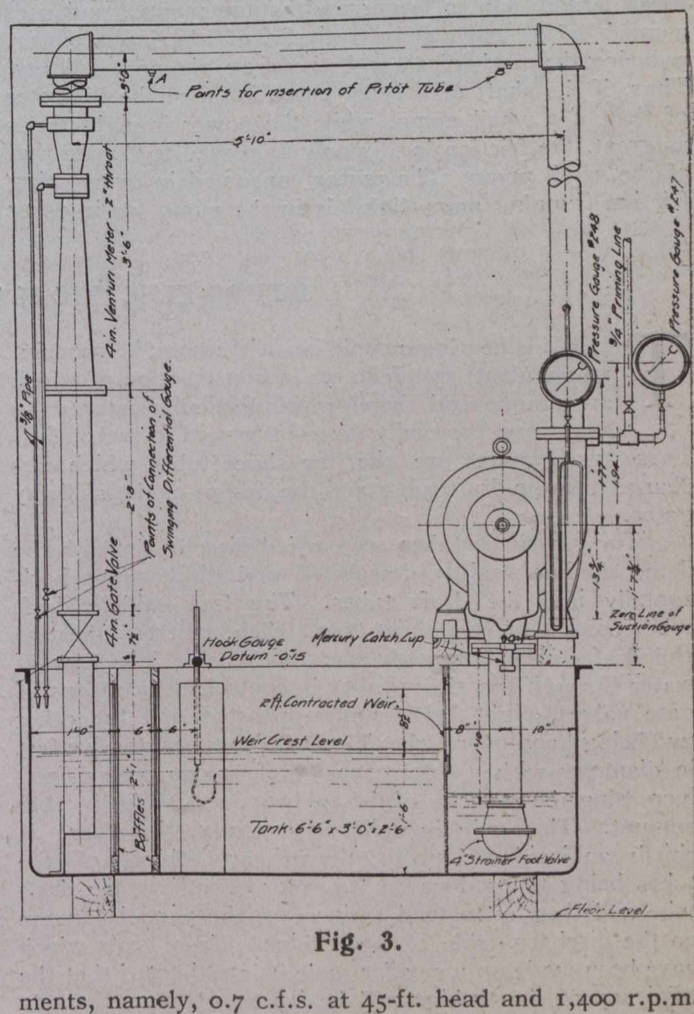


Fig. 3.

Test of 4-in. Single Stage Turbine Pump
—Test Data Corrected to Constant Speeds—

Table No. 3.

No	Test Speed	Speed N	Head H	Disch. Q	Power P	Effy E
1	2	3	4	5	6	7
1	995	1000	15.40	0.722	1435	48.1
2	995		21.10	0.613	1388	58.1
3	995		24.30	0.517	1330	58.8
4	1000		27.09	0.411	1248	55.6
5	1000		28.50	0.326	1057	54.8
6	1004		28.00	0.252	958	45.9
7	1004		27.00	0.195	890	36.9
8	1005		25.05	0.124	780	25.0
9						
10						
1100 R.P.M.						
11	1093	1100	18.45	0.785	1775	50.9
12	1105		25.50	0.676	1682	63.8
13	1090		28.45	0.596	1700	62.2
14	1090		31.40	0.503	1617	61.5
15	1100		33.33	0.410	1458	58.4
16	1100		34.40	0.333	1330	53.7
17	1100		33.98	0.265	1175	47.8
18	1105		32.60	0.189	1034	37.7
19	1109		30.80	0.128	903	27.2
20	1110		17.70	0.106	899	13.0
1200 R.P.M.						
21	1190	1200	21.50	0.835	2168	51.4
22	1200		29.51	0.735	2082	64.9
23	1186		33.20	0.625	2053	63.0
24	1187		37.10	0.517	1938	61.7
25	1190		39.10	0.419	1772	57.6
26	1195		40.30	0.339	1622	52.6
27	1195		39.50	0.263	1449	44.8
28	1200		37.03	0.190	1282	34.2
29	1195		35.65	0.120	1120	23.9
30	1195		18.65	0.072	1085	7.5

No.	Test Speed	Speed N	Head H	Disch. Q	Power P	Effy. E
1	2	3	4	5	6	7
31	1295	1300	25.30	0.862	2585	52.0
32	1300		34.84	0.756	2532	64.8
33	1300		38.93	0.651	2483	63.6
34	1300		43.09	0.544	2360	61.9
35	1300		46.63	0.436	2178	58.2
36	1300		47.04	0.355	2075	50.2
37	1300		45.34	0.276	1802	43.2
38	1300		43.30	0.193	1553	33.5
39	1300		41.20	0.120	1363	22.6
40	1295		24.15	0.097	1353	10.8
1400 R.P.M.						
41	1400	1400	29.46	0.892	3065	53.5
42	1410		38.80	0.799	3005	64.3
43	1410		44.50	0.696	2965	65.3
44	1410		49.80	0.588	2820	64.7
45	1410		53.10	0.494	2675	61.0
46	1410		55.00	0.411	2545	55.8
47	1410		53.70	0.334	2245	49.6
48	1400		51.76	0.260	1970	42.6
49	1400		50.31	0.196	1797	35.2
50	1400		46.97	0.136	1583	25.1
1500 R.P.M.						
51	1500	1500	33.59	0.923	3720	51.9
52	1500		46.10	0.805	3735	62.0
53	1500		56.07	0.696	3550	68.6
54	1500		58.24	0.593	3315	65.0
55	1500		61.25	0.497	3185	59.6
56	1500		64.06	0.419	2835	59.0
57	1490		62.10	0.333	2605	49.5
58	1490		59.00	0.262	2335	41.3
59	1500		56.14	0.191	2140	31.3
60	1500		50.77	0.136	1955	22.0

Table No. 3.

altogether although the valve was still apparently partly open. This may have been due to the type of valve employed which was simply a standard 4-inch gate valve with a certain amount of play in the disk which would render the necessary fine adjustments impossible. It may also have been due to the fact that the head in the upright discharge pipe to the elbow was greater than the head corresponding to this small discharge and the pump discharge thus simply fell off, no water passing along the horizontal portion of the discharge pipe. The conditions changed so rapidly at the small discharges that no results could be obtained.

The curve of efficiency is of good form, giving, as was to be expected, maximum efficiency at normal discharge and being comparatively flat at this point so that for slight increase or decrease of discharge the change in efficiency is slight.

The efficiencies obtained are quite high for a pump of this size acting under so low a head, being slightly over 65 per cent. Although customary in large multi-stage pumps to obtain efficiencies in the neighborhood of 80 per cent., efficiencies of 60 per cent. or over may be considered very good in pumps of this size. In small single-stage pumps the bearing and gland friction is relatively much larger than in larger multi-stage pumps, and uses a much larger part, comparatively, of the input power, reducing the mechanical, and, therefore, the net efficiency. Thus, if the shaft of a large pump is twice the diameter of that of a small pump, while the power is eight times as great, the friction loss is only increased to double that of the small pump. The power consumed in overcoming friction (running pump light) is in the pump, as in other machines, a certain fraction of the total input, and this fraction decreases as the pump increases in size, so that evidently higher mechanical efficiencies should be expected in pumps of large size than in small size ones. Such efficiencies as have been obtained from this pump are the result of very careful design and accurate workmanship, which in turbine pump work are absolute necessities when high efficiencies are sought. In addition, as previously mentioned, the impeller and guide-ring, guides, passages and surfaces were all finely finished and polished in this pump, the construction being so modified as to permit of this being done.

HYDRO-ELECTRIC PLANT OF UNUSUAL DESIGN.

THERE is nearing completion at Wissota, Wisconsin, a new plant, two features of construction of which are unique and therefore of particular interest to engineers, especially those interested in hydraulics. These two features are the ten sluice tubes which discharge into the draft tubes and the design of the spillway gates.

The ten sluice tubes are carried directly through the dam, sloping slightly downward and discharging horizontally into the draft tubes. The four middle draft tubes consist of two sluice tubes each, whereas the two end draft tubes have only one tube each. The flow of water through the sluice tubes is controlled by means of gate valves, eight being motor-operated and the other two being hand-operated. These sluice tubes are five feet in diameter with a total capacity of 10,000 second-feet, increasing the capacity of the spillway, obviously, by that amount. This gain in spillway capacity, however, is chiefly an incidental result, the primary object of the tubes being to produce an "injector effect" in the draft tube and thereby to tend to increase the partial vacuum on the discharge side of the turbine. From tests which have been made on a smaller scale it is estimated that the efficiency of the turbine will be increased approximately four per cent. by this arrangement. At present, efforts are being made to secure a patent on this particular type of tube. It is understood, of course, that the sluice tube will be used only when the river is supplying water in excess of that being used by the plant.

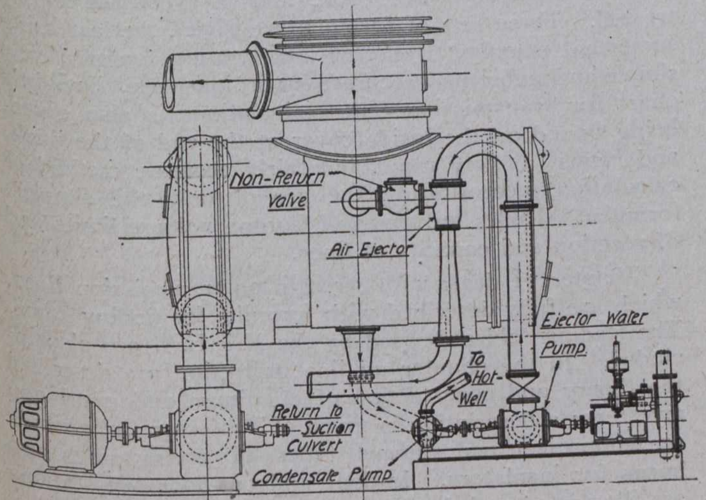
The spillway gates, thirteen in number, each sixty-four feet wide, are of the type known as the Stauwerke automatic gate. As mentioned, this design of gate has never before been used in America, but is said to be giving remarkably good service in Switzerland under conditions very similar to those prevailing at Wissota. The gate is mounted on a horizontal axis at right angles to the stream, and is so adjusted that a counterweight just balances the pressure of the water at normal level. Any slight rise of level thereby increases this pressure and tilts the gate, thus permitting a much greater quantity of water to pass through the spillway. These gates are expected to regulate the water level of the pond to within four inches of normal under all ordinary conditions, and never to allow it to rise more than six inches above normal even under the most extreme conditions. In addition to being automatic and providing close regulation, the Stauwerke gate possesses a third advantage in that it is curved downstream and hence presents a concave surface to the stream. This design prevents all clogging by drift or ice.

With these two distinctive ideas in dam construction being thus tried on a large scale, the results which the Wisconsin-Minnesota Company obtains at Wissota will no doubt be well worth the attention of all engineers interested in hydraulic power development.

TESTS ON SURFACE CONDENSING PLANT.

FOLLOWING are the results of tests carried out on one of five similar surface condensing plants with Willans rotary air pump system, installed at the Durnsford Road power house of the London & South Western Railway Co., England:—

	Test No. 1.	Test No. 2.	Guarantees.
Load, lbs. of steam per hour	68,176	68,389	68,000
Vacuum at steam inlet to condenser, corrected to 30" barometer	28.73"	28.76"	28.5"
Corresponding steam temp.	86.6° F.	86° F.	92° F.
Condensate temperature	82° F.	82.5° F.	87° F.
Difference between condensate and vacuum temperatures.	4.6° F.	3.5° F.	5° F.
Circulating water inlet temp.	58.5° F.	58.5° F.	65° F.
" " outlet "	80.8° F.	81.1° F.	83° F.
Difference between circulating water outlet and vacuum temperatures	5.8° F.	4.9° F.	9° F.
Cooling water, gals. per hour	318,000	317,600	396,600
Duration of test	60 min.	60 min.	



The tests were carried out after the plant had been in service for a considerable period, and in the presence of the representatives of the consulting engineers, Kennedy & Donkin, and of Herbert Jones, chief electrical engineer of the railway.

As mentioned above, the station contains five identical plants in addition to two smaller similar plants. Each of the plants embodies the rotary air pump system devised by Willans & Robinson, Limited, of Rugby, England. The main feature of this system is that the circulating water is passed through an ejector, which is shown in the accompanying drawing, and which takes the place of the ordinary air pump. A separate condensate pump is provided to withdraw the condensed steam from the surface condenser and to return this to the hot well. An automatic non-return valve is placed between the air ejector and the main condenser body, so as to prevent water being drawn into the condenser in case of failure of the ejector.

There are three common forms of application of the system known as the "series," the "shunt" and the "separate pump" types. In the case of the "series" type of plant, the whole body of the circulating water is passed through the air ejector before entering the condenser. That is, the circulating pump is designed for the normal quantity of water required by the condenser, but allowance is made in calculating the head for the necessary drop across the air ejector.

In the case of the "shunt" system, the cooling water for the condenser and the ejector water are delivered in parallel, and the ejector water is returned to the source of supply or to the circulating water suction. In other words, the circulating pump is designed for the normal head required by the lay-out of the plant with allowance for condenser friction and the quantity delivered is that needed for the condenser itself, plus the necessary water for the air ejector.

The "separate pump" type, of which the L. & S. W. installation is an example, differs from the "shunt" system only in that a separate pump is provided for delivering the air ejector as apart from the main circulating water pump which supplies the condenser in the ordinary way.

In the L. & S. W. installation, both the main circulating pump and the ejector pump draw their water by means of a common suction pipe from the main suction culvert, which runs the full length of the engine room. The water coming from the condenser itself is, of course, heated and passed to the delivery culvert, but the air ejector water is returned to the suction or inlet culvert.

It will be noted that in this instance the circulating pump is driven by means of a continuous current motor, whereas the ejector pump and condensate extraction pump are driven by a small steam turbine.

The tests show that the vacuum attained is substantially above that guaranteed, and that there is very slight difference between the circulating water outlet and vacuum temperatures.

PIPES OF ELECTROLYTIC IRON.

A firm at Grenoble, in France, is now manufacturing pipes of electrolytic iron up to five metres (16.4 ft.) in length, 300 mm. (nearly 12 in.) diameter and 3 mm. (⅛ in. bare) thick. The metal as taken from the bath is hard and very brittle, but after a special and careful heat treatment becomes of excellent quality and has a tensile strength of over 25 tons per square inch in any direction. They are stated to be superior to cast-iron pipes in several respects.

AMERICAN LOCOMOTIVE BUILDING.

The demand for locomotives in the United States continues active. The Southern Railroad Co. contemplates buying 45 engines, the Chicago, Burlington and Quincy 30, the Union Pacific 15 and the Duluth, Mesaba and Northern 6. The American Locomotive Co. will build 40 consolidation engines for the Italian State Railways, 10 Pacifics for the El Paso and South-Western Railroad, and 5 each for the Delaware, Lackawanna and Western, the Central Railroad of New Jersey and the Western Pacific. The Louisville and Nashville is building 8 Mikados in its own shops, and will soon begin 8 more.

The Southern Canada Power Co., Limited, have removed from 43 St. Francois Xavier St., to 330 Coristine Building, Montreal.

The mining industry in Spain has acquired more importance than is generally known. The output of iron ore in 1915 was 5,617,839 tons. Pyrites were raised to the extent of 730,568 tons; iron ore briquettes to the extent of 555,357 tons and manganese ore to the extent of 14,328 tons.

The promoters of the Oriental Iron Smelting Co., of Japan, propose to work the Taochun iron mine at Anhui, China, by taking over a concession obtained by the Chino-Japanese Industrial Development Co., from the Peking Government. The company proposes to start with a capital of $12,462,500.

The Engineer's Library

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

CONTENTS.

BOOK REVIEWS.

Hydro-Electric Power—Vol. II. Electrical Equipment and Transmission. By Lamar Lyndon. Published by the McGraw-Hill Book Co., New York. First edition, 1916. 360 pages, 194 illustrations, 28 tables, 6 x 9 ins., cloth. Price, $3.50. (Reviewed by H. D. Johnston, contract manager, Eugene F. Phillips Electrical Works, Limited, Montreal.)

The book is divided into thirteen chapters, the first five of which deal with power house equipment, seven with transmission lines, and the last with sub-stations.

Considering the scope of the book, the subjects are very thoroughly dealt with, particularly the sections dealing with transmission lines.

Chapter 1 contains a short description of generators and exciters. This subject, however, is dealt with only in a general manner, and a more detailed description of some of the modern large generators mentioned would be interesting.

Chapter 2 describes in a practical manner the various types of transformers. The different methods of connection are clearly discussed and the theory explained with the aid of simple formulæ and vector diagrams.

The chapter on switch-boards contains descriptions of various types of modern switch-boards, considerable attention being given to exciter boards in connection with which is shown a diagrammatic method of computing bus-bar currents. Clear descriptions are given of all the usual instruments and accessories used in the modern power house, including the Tirrell regulator and the multi recorder. The chapter closes with specifications for high-tension switching apparatus

In the chapter on power house cranes some of the reference letters for clearances are omitted on the diagram, and figures referred to in the text at the end of the chapter are wrongly numbered.

An outline is given of power house design, but, as the author points out, no definite rules can be laid down owing to the widely differing conditions of each undertaking. In the same chapter, tests on hydraulic turbines and generators are described.

Wires and cables for transmission lines are discussed in Chapter 6 with a comparison between aluminum and copper lines, the author indicating a preference for the former.

One chapter is devoted to insulators for high-voltage lines and a good description is given of modern insulators, advising the points to be considered in their selection and including the American Institute of Electrical Engineers' specifications for testing insulators. Pole and tower lines are fully described in Chapter 8, including detailed descriptions of materials and erection. Some useful formulæ and tables are given, also specifications for material and a comparison of costs between a pole line and steel tower line.

In the chapter on electric circuits the author very clearly explains the theory of A.C. circuits by means of diagrams and concisely written text.

The chapter on calculation of transmission lines is perhaps the best in the book, and is very thoroughly treated. Three sets of formulæ are given, the last being somewhat complex, while the first two are comparatively simple and sufficiently accurate for ordinary use. Dwight's chart for transmission line calculations is also given, being bound on the inside cover at the end of the book, and forms a very rapid and fairly accurate method of calculation, necessitating the use of only the simplest formulæ. Tables are given of Corona voltage limits and of reaction and capacity of lines.

Chapter 11 deals with stresses on transmission lines, which are fully described with formulæ for finding same. The leading tables devised by the N.E.L.A. are also included. In the chapter on line protection are described the theory and construction of aluminum and multi gap arresters; a description is given of Professor Creighton's arc suppressor and various types of arcing rings and horns for insulators. In-door and out-door sub-stations are illustrated and described in the last chapter.

The book is well printed, the diagrams being very clear and all formulæ, of which there are some 146, being numbered for reference.

No mention is made of underground cables, and as these are becoming more extensively used in connection with transmission lines for voltages up to 25,000, a short chapter on the subject giving some details of their construction and method of installation might have been included with advantage.

The author has covered very completely the subjects enumerated and the book will be found very valuable not only to the student but also to the engineer.

Mechanical Equipment of Buildings—Vol. I., Heating and Ventilating. By Louis Allen Harding and Arthur Cutts Willard. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1916. 615 pages, illustrated, 6¾ x 9¼ ins., leather. Price, $4.00 net. (Reviewed by Harry H. Angus, B.A.Sc., MacMullen, Riley and Angus, consulting engineers, Toronto.)

This book is the first of a series of books being written by the same authors and dealing with the mechanical equipment of buildings. This first volume deals only with heating and ventilation of buildings and other items such as power plants, elevators, lighting systems, etc., are to be dealt with in subsequent volumes.

The present book without doubt contains the best and most complete information of any book so far published in connection with heating and ventilation. The authors have drawn upon all available sources of information and have grouped this into such form that it is ready for quick reference. The method of using the different formulas is well explained by means of various examples and it is to be noted that practically all examples are those dealt with in actual practice. In a great many cases all the calculations required in the complete design of a system for a particular building are made and explained. Very little space has been devoted to electrical heating and other questions which at present are of merely theoretical interest and the whole book is arranged to deal with the practical problems which are met with every day. Particular care has been taken in grouping the information and credit has been freely given in the text to the sources from which all information has been obtained. The illustrations in most cases are drawn to scale and are typical working drawings and much superior to the usual type of drawings found in books of this type. They are also very numerous and all points brought out in the text are well illustrated, thus making the book comparatively easy to follow. This book also contains a great deal of original information, particularly that giving tests on different types of boilers and radiators. Up to the present time, the books published dealing with heating and ventilation have been either very elementary or have only dealt with one phase of the question so that practically all published information had to be gathered from papers read before engineering societies and from short articles.

The authors have therefore given to heating engineers a pocket book quite as valuable along this line as Kent's pocket book is to mechanical engineers.

The first and second chapters deal with the properties of steam, water and air which are required in dealing with the science of heating and ventilation. Chapter 3 gives information regarding the heat transmission of various types of building construction and consists of information collected from various sources and placed in a form ready for reference. The next chapter gives information regarding the standard types of radiation at present in use as well as data regarding the heating effect of radiators under different conditions. The next chapters deal with fuels and boilers. The question of fuels is gone into very fully as well as various methods of testing both fuels and flue gases. Under the head of boilers is given a number of tests and comparison of different types but the question of smokeless combustion is not dealt with as fully as might be desired, in view of the present widespread interest in the elimination of smoke nuisance in cities. The chapters dealing with steam and hot water heating are quite complete and in addition to the usual information, describe the different appliances and systems on the market, giving cuts and general dimensions as well as typical arrangements and design of systems. The question of friction in hot water systems is dealt with thoroughly and charts and formulas given and explained. Forced hot water and vacuum steam systems for large plants are dealt with later in the book.

In the latter part of the book is given some excellent reference information regarding pipe sizes, valves, fittings and also valuable data on pipe hangers and supports, a good deal of which has not been published before.

Six chapters are devoted to hot air heating, covering furnace heating, indirect heating, forced blast heating and air washing. This part of the book is well written and contains much valuable information required in dealing with hot air heating, and sufficient information to solve any problems arising in this connection. The question of friction in air ducts is carefully dealt with and formulas and charts are given which are required to design a balanced system.

Numerous plans of buildings are shown in order to deal fully with the problems involved and the design of systems for these buildings is shown together with all calculations required. Suitable designs of fans as well as their proper location and connections to the duct system are described and shown as well as methods for fan testing. The chapter dealing with air conditioning contains the latest data on this important subject, including a table giving the properties of mixtures of air and saturated water vapor as well as a psychrometric chart worked up by one of the authors.

Spon's Electrical Pocket-Book. By Walter H. Molesworth. Published by E. and F. N. Spon, Limited, London; Spon and Chamberlain, New York. 488 pages, 325 illustrations, 6¾ x 4¼ ins., cloth. Price, $1.75 net. (Reviewed by Alfred S. L. Barnes, Hydro-Electric Power Commission of Ontario, Toronto.)

The preface sets forth that this book is written for practical engineers who may seek for general information, tables and formulæ on electrical subjects. It is a handy and useful compilation covering, for its size, a very considerable range of data, mainly electrical, of which a good portion will be of general utility anywhere. So far as this country is concerned, however, there are several sections which would be of little use, *e.g.*, the British Home Office Regulations, the British Board of Trade Regulations, the Rules of the Institution of Electrical Engineers, the sections on tramways and railways and the British standardization rules for electrical machinery. The book is convenient in size and the information is arranged in suitable sequence and there is a copious index at the end consisting of some 20 pages.

Stresses in Structures. By A. H. Heller, C.E., late professor of structural engineering, Ohio State University. Third edition, 1916, revised by his successor, Clyde T. Nanis, Mem.Am.Soc.C.E. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal. 374 pages, 230 diagrams, 6 x 9 ins., cloth. Price, $2.75 net. (Reviewed by A. H. Harkness, Harkness & Oxley, consulting engineers, Toronto.)

The first edition of this work was the publication of the manuscript used by the author for his lectures in the university. This third edition has been revised and the explanations expanded so as to make the work more easily read by the beginner. It follows that the book has been written from the standpoint of a lecturer who wished to produce a text book for his students rather than a reference book for the profession of engineering. As a text book to be read in conjunction with a course of lectures it would be very useful. The student who wished to use the book for self instruction would probably find it too condensed to enable him to follow it readily. He would, moreover, require a good grounding in mathematics to be able to do so at all. The busy engineer who wishes to refresh his memory, or to get information on some of the subjects covered in the book, will be able to do so with a minimum amount of reading.

The book, within its limit of 350 pages, covers practically the whole subject of strength of materials, and status of beams and determinate trusses. The first and second chapters treat of stresses and deformations in materials. The third chapter deals with coplaner forces, the laws of equilibrium and their application, and the fourth and fifth chapters with the methods of determining the stresses in trusses. The sixth, seventh and eighth chapters form a fairly complete treatise on the beams, covering the stresses in beams and girders, the deflection of beams, the bending moments and shears in simple beams, and in restrained and continuous beams. The question of live loads with maximum moments, and shears, for simple and continuous beams is also discussed. The ninth chapter is devoted to columns and the tenth, eleventh and twelfth to roof and bridge trusses with stationary loads. Chapter thirteen covers railroad bridges with moving loads, and fourteen treats of horizontal loads on bridges, lateral bracing and portals. Each of the above subjects is more completely covered than one would expect to find in a book of this size.

The order in which the different subjects are taken up and discussed is not that usually followed in text books, but it is logical. It may, however, require a little harder application on the part of the student to follow the work.

One feature that commends itself is the author's method of analyzing a stress condition in some simple structure or shape, and solving it by ordinary mathematics before going into the higher mathamatical analysis of it. This is well illustrated in his discussion of the moment of resistance of the beam where he shows how to find the moment of resistance of a rectangular beam by elementary mathematics and statics. The result is that the student gets a much clearer conception of the meaning of the more complete mathematical analysis which follows. Too often in text books the discussion of a problem begins and ends with the mathematical analysis.

PUBLICATIONS RECEIVED.

Annual Report, 1916, of the Canada Iron Foundries, Limited, Montreal.

American Waterworks Association.—Proceedings of the 36th year of the American Waterworks Association, Baltimore, Md.

Handbook on Wood Preservation.—Published by the American Wood Preservers' Association, Mount Royal Station, Baltimore, Md.

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

Mineral Production.—A general summary of the mineral production of Canada during the calendar year 1915. Issued by the Department of Mines, Ottawa.

Dominion Water Power Branch.—Annual report, 1914-1915, of the Water Power Branch, Department of the Interior, Ottawa. J. B. Challies, C.E., superintendent.

Subsidence Resulting from Mining.—By L. E. Young and H. H. Stoek, being Bulletin No. 91 of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Operating Details of Gas Producers.—By R. H. Fernald. Bulletin 109 issued by the Bureau of Mines, Department of the Interior, Washington, D.C. Van H. Manning, director.

American Society for Testing Materials.—Proceedings of the 19th annual meeting of the society held at Atlantic City, N.J., June 27-30, 1916. Part 1 contains committee reports and tentative standards, and Part 2 technical papers.

Department of Trade and Commerce.—Canada year book, 1915. Valuable reference volume. Special articles on "Local Government of Canada," "Economic Geology Flora and Fauna of Canada." Section 8 devoted to statistics of railways, canals, telegraphs, telephones, etc. Price, $1.00.

International Marine Diary, 1917.—The object of this useful volume is to supply the commercial world in concise form, data relative to the development of Great Britain's trade with foreign countries. Sterling conversion tables, the shipping, banking, postal, cable, and financial facilities of each country listed are given. Price, five shillings and ninepence. Published by Syren and Shipping, 91 Leadenhall Street, London, E.C.

CATALOGUES RECEIVED.

Wedge Optical Pyrometer.—An 11-page illustrated pamphlet issued by Barnes & Morris, London, Eng.

Holt Roof Vent and Leader Connections.—Illustrated booklet containing 19 pages, issued by The Barrett Company, New York.

American Drilling Machines.—Catalogue No. 145 of The American Well Works, Aurora, Ill., contains 112 pages, and is well illustrated.

London Concrete Block Machine.—A 40-page illustrated booklet issued by The London Concrete Machinery Co., Limited, London, Ont.

Gun-crete for Protection.—Bulletin No. 5 of the Cement-Gun Construction Co., Chicago, Ill., describing, with illustrations, their Gun-crete work on various buildings.

Buda Electric Storage Battery Trucks.—Illustrated folder issued by The Buda Company, Chicago, Ill., through their agents, the Federal Engineering Co., 92 Sherbourne Street, Toronto.

Lubrication.—A 12-page illustrated leaflet published by The Texas Co., New York, containing articles on flash and fire tests, the Universal Unaflow engine, lubrication of sugarhouse machinery, etc.

Sun Oils.—Volumes 1, 2 and 3 of a series of pamphlets issued by the Sun Co., 1428 South Penn Square, Philadelphia, Pa., descriptive of the early days and later developments of the oil business.

Lubrication.—A 16-page illustrated pamphlet published by The Texas Co., 17 Battery Place, New York City, describing steam cylinder lubrication, modern apparatus for the scientific lubrication of machinery, etc.

American Standard Types of Centrifugals.—Catalogue No. 132 of The American Well Works, Aurora, Ill., describing their standard types of American centrifugal pumps. Contains 104 pages and is well illustrated.

Spraco Equipment.—Bulletin No. 250, issued by the Spray Engineering Co., 93 Federal Street, Boston, Mass., which illustrates and describes their "Spraco" equipment for washing and cooling the ventilating air for steam turbine-driven generators.

American Deep Well Pumps.—Illustrated catalogue No. 130, issued by The American Well Works, Aurora, Ill. This catalogue, comprising 63 pages, contains two sections. Section 1 describes American deep well power heads, and Section 2, American deep well steam pumping engines.

Editorial

COMPENSATION OF ENGINEERS.

According to a report made to the American Society of Civil Engineers by a special committee, the average compensation of engineers is $3,985 per annum. The research work of the committee was supposed to have been conducted among non-members as well as members of the society. Engineering Record, of New York, in commenting editorially upon this report, scouts the idea of the average engineer's income being so near the $4,000 mark, and states that the committee should withdraw its report. We entirely agree with our contemporary in this matter and feel certain that the average compensation of civil engineers on this continent—counting in all classes—is considerably less than $3,985.

The average income of the members of the American Society of Civil Engineers may be that amount, but the average salary of engineers who are not members of the society would be so much lower that it would materially reduce the total general average. Data was obtained from 5,042 out of 7,037 members of the society, but only 1,316 non-members reported to the committee.

The committee itself acknowledges that low-salary data is lacking and explains that it was difficult to arrive at the salaries of engineers in state, municipal and railroad employ, etc. Engineering Record points out that a census of the engineers employed in the eastern district of New York State shows 253 men with an average compensation of $1,775. Only eight were up to the committee's average of $3,985. Of these 253 men only 44 were found in the membership list of the society with an average of $2,857, leaving an average of $1,547 for the other 209. This suggests the unreliability of returns which are compiled mainly from members of the society.

No doubt the report of the committee of the American Society is an extremely valuable document and shows the average remuneration of the members of that society, but it evidently cannot be taken as a fair determination of the average compensation of civil engineers in general.

AFTER-THE-WAR PROBLEMS.

During the past few weeks there have been held the annual meetings of some of our important banking and financial institutions. At many of them there have been delivered addresses which have dealt more or less fully with the trade conditions that are likely to obtain after the war. One of the most remarkable of these addresses was that delivered by Sir Herbert Holt at the annual meeting of the Royal Bank of Canada a few days ago. He pointed out that the present prosperity had no permanence about it and that the war was the only thing which had accelerated the wheels of industry; that the termination of the war must react on all industry with very far-reaching results. Factories that were now running full time and overtime and were exclusively engaged in the manufacture of munitions would close. Kindred industries, stimulated by high prices, would suffer by the return of more ordinary conditions. Exports, he anticipated, would decline as Europe imported less and commodity prices would recede. Labor will become a glut in the market, only to be aggravated by the return of soldiers in large numbers.

Leaders of thought in all parts of the Dominion have pleaded and are still pleading for some intelligent action to be taken in order to solve the problems which must confront us as a people after the war is over. The great majority of our people are seized of the importance of action in this direction.

It seems that practically every country in the world is exercising itself in intelligent effort to meet and solve these problems in a businesslike way except Canada. Is it not foolish for us as a people to go blundering along trusting that something will turn up which will enable us to evade the difficulties which other nations feel sure are bound to confront them when hostilities cease.

ENGINEERING SOCIETIES AND THE WAR.

While it will be generally conceded that technical societies were founded for scientific and educational work and that they would be going out of their province if they began meddling with matters of trade and industry, there is, nevertheless, a growing conviction on the part of many members of such societies that the time has come for some of them, at least, to concern themselves with the business side of engineering more than they have done in the past.

There is much to be said on both sides of this question. We have great respect for those who maintain, and maintain stoutly, that it is not the function of a technical society to discuss, for instance, the matter of workmen's compensation, or the limitation of profits. These and kindred subjects are suitable for boards of trade, but not for the technical society. The discussion of business questions should be left to business organizations, but the technical society should confine itself to scientific discussion.

Undoubtedly the view that our scientific societies should lend themselves more generally to the discussion of business matters has been accentuated since the war introduced a new series of economic problems, in the solution of which science will be called upon to play a most important part.

If, as is so often stated, science is to be the ruling factor in the race for national supremacy after the war, would it not seem to be the wiser course for societies which were created for the consideration of scientific questions to stand by their guns and not permit their energies along that line to be scattered by the introduction of discussions of a totally different character?

ANNUAL CONFERENCE OF COUNTY ROAD SUPERINTENDENTS AND ENGINEERS.

We have been sent a programme of the third annual conference on road construction for county road superintendents and engineers. This year the conference is to be held March 27th to 30th,

These yearly conferences which are held under the auspices of the Ontario Department of Public Highways cannot but be effective and beneficial in a number of ways, not only to those who are privileged to attend but to highway engineering generally. They foster a spirit of co-operation between the engineers of the Provincial Department of Highways and the men out in the field who are carrying out the actual work, which is most desirable. At these annual conferences the questions growing out of the design, construction and maintenance of county roads are freely discussed. They constitute a clearing house for ideas and the experience gained at them cannot help but lead to a broader and better understanding of road work.

PERSONAL.

JOHN FAIR has been elected chairman of the water commission, Brantford, Ont.

J. ARCHIBALD KERR has been elected chairman of the Water Commission, Petrolia, Ont.

Dr. J. A. AMYOT, director of the Ontario public board of health laboratories, Toronto, has been appointed sanitary adviser in England to the Canadian forces.

S. W. BARNSTEAD, C.E., has been appointed engineer for the Holden end of the big drainage scheme in the district of Holden and Daysland municipalities, Alberta.

Lieut. J. V. DILLABOUGH, A.M.Can.Soc.C.E., for the past four years assistant chief engineer of the Hudson's Bay Railway, has been appointed second in command of the 228th Battalion, Winnipeg.

E. EVANS, formerly inspector of the sewer maintenance department, Edmonton, Alta., has been appointed superintendent of the sewage disposal plant with control of all matters pertaining to the sewers of the city.

F. J. GLOVER, municipal engineer, Langley, B.C., has enlisted for overseas service, and will leave for England in about six weeks' time, in charge of a tunnelling company with the Engineers of North Vancouver.

Capt. A. GERALD KNIGHT, a graduate of the Department of Applied Science and Engineering of the University of Toronto, who recently was reported to have been awarded the D.S.O., and later the M.C., is now reported missing.

F. P. BRADY, general superintendent of the Canadian Government Railways, who has been a patient in a Rochester, Minn., hospital for the past four months, is so far recovered as to be able to return to Winnipeg, but not yet able to return to duty.

Lieut.-Col. F. O. W. LOOMIS has been awarded the D.S.O. He was, prior to the war, a member of the Montreal contracting firm of D. C. Loomis & Sons. He went to the front with the first Canadian contingent, and is now with the headquarters staff in England.

J. G. MAYO, formerly assistant general manager of the Mattagami Pulp and Paper Company, has joined the sales staff of the Canadian Fairbanks-Morse Co., Limited, with headquarters at Montreal, as head of that firm's newly organized pulp and paper mill department.

A. E. GRIFFIN, of the firm of Foley, Welch & Stewart, Vancouver, B.C., has been asked to report at once in England. He is to be given charge of a corps of railway construction men. The appointment has been made by Col. J. W. Stewart, deputy director of light railway construction in France.

M. A. GRAINGER, for the past two years acting chief forester for the forest branch of the Department of Lands, British Columbia, has been appointed to the office of chief forester in succession to Mr. H. B. MacMILLAN, who recently resigned to accept the position of assistant manager of the Victoria Lumber and Manufacturing Company, with headquarters at Chemainus, B.C.

Capt. H. A. WOOD, son of Mr. D. O. Wood, general freight agent of the Allan Line, Toronto, has recently received his promotion to flight commander, with rank of captain. Capt. Wood is a graduate of the School of Practical Science, Toronto, 22 years old, and was with the engineering staff of the Toronto Harbor Commission prior to going overseas.

Second-Lieut. YVES LAMONTAGNE, of the Royal Engineers, was wounded on the 12th of January. Lieut. Lamontagne had just been graduated in Applied Science at McGill University when he enlisted as a private in a railway construction corps in July, 1915. He went to the front with that unit and in January of last year was transferred to the Royal Engineers, and given his commission as second-lieutenant. He is at present serving with the 74th Field Company. His home is in Montreal.

JESSE K. GIESEY has been admitted to partnership in the firm of Geo. W. Fuller, consulting engineers, New York City, and the firm name has been changed to FULLER & McCLINTOCK. Mr. Jas. R. McClintock has been associated with Mr. Fuller for a number of years. Mr. Giesey graduated at Rensselaer Polytechnic Institute in 1904. He was a member of the staff of Hering & Fuller, 1904-11; assistant engineer with Hering & Gregory, 1911-14; and latterly in charge of the outfall sewer, pumping station and sewage treatment works at York, Pa.

Major E. G. M. CAPE, president of the E. G. M. Cape & Co., Limited, contractors, Montreal, was mentioned in the recent despatches by Field Marshal Sir Douglas Haig. Major Cape commands the 106th Battery Canadian Heavy Siege Artillery, one of the finest batteries that ever left Canada. Major Cape, who is a B.Sc., was at one period lecturer on mechanical engineering at McGill University, and has also held positions with public companies. He is a member of the Canadian Society of Civil Engineers.

OBITUARY.

Lieut. RONALD HAYWARD, son of Mr. R. F. Hayward, general manager of the Western Canada Power Company, Vancouver, B.C., who joined the Royal Horse Artillery in England, was recently killed in action at Salonika.

R. E. SPEAKMAN, city engineer of Brandon, Man., for the past nine years, passed away in a Rochester, Minn., hospital on January 13th at the age of 70 years. Mr. Speakman was also city engineer of St. Catharines before going to Brandon, and at one time had an office in Toronto. He was a member of the Canadian Society of Civil Engineers.

CORRECTION.

In last week's issue in the article "Analysis of Chicago By-law for Flat Slabs," by W. W. Pearse, Equation 19 should have read: $Mt = wL^3/28.5$. Equation 20 should have read: $Mt = WL/28.5$. The line just before Equation 1 should have read: $Mt/2 = wL^3/57$.