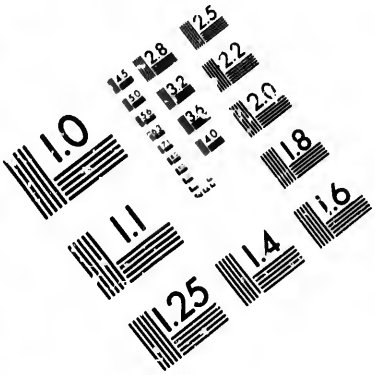


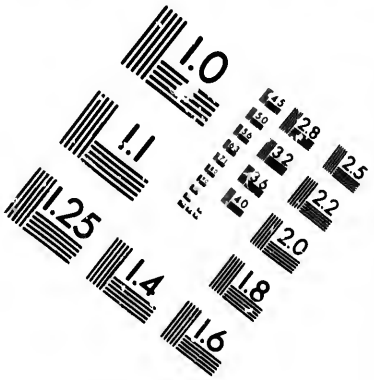
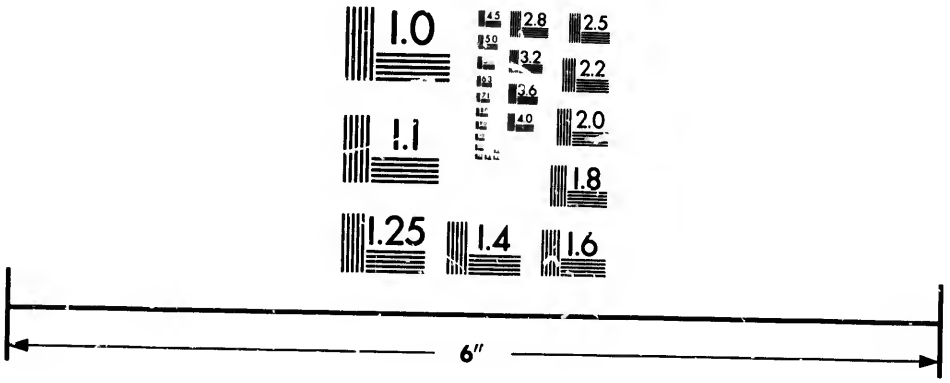
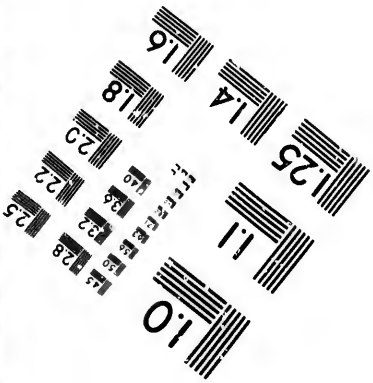
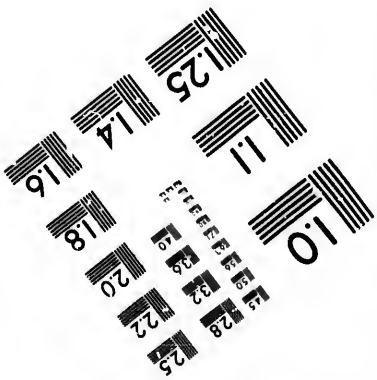


IMAGE EVALUATION
TEST TARGET (MT-3)







Photographic
Sciences
Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

- [x] Coloured covers/ Couverture de couleur
- [x] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [ ] Bound with other material/ Relié avec d'autres documents
- [ ] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distortion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments:/ Commentaires supplémentaires:

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [x] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Includes supplementary material/ Comprend du matériel supplémentaire
- [ ] Only edition available/ Seule édition disponible
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
						✓					

The copy filmed here has been reproduced thanks to the generosity of:

National Library of Canada

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol ⟶ (meaning "CONTINUED"), or the symbol ∇ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:

L'exemplaire filmé fut reproduit grâce à la générosité de:

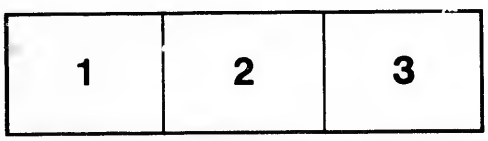
Bibliothèque nationale du Canada

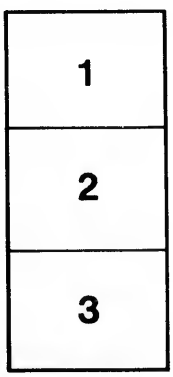
Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

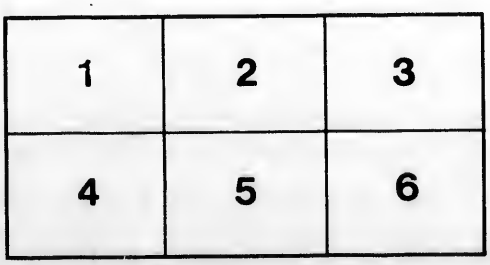
Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole ⟶ signifie "A SUIVRE", le symbole ∇ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.







TORONTO

WATER WORKS INVESTIGATION.

REPORTS

—OF—

His Honor Judge McDougall, J. J. Mason, C. F. Hanson, Prof. Galbraith and Edwin Jones.

Read in the City Council October 24th, 1887.

TORONTO:
E. F. CLARKE, CORPORATION PRINTER, 33 AND 35 ADELAIDE STREET WEST.
1887.

TORONTO

WATER WORKS INVESTIGATION.

REPORTS

—OF—

His Honor Judge McDougall, J. J. Mason, C. F. Hanson, Prof. Galbraith and Edwin Jones.

Read in the City Council October 24th, 1887.

TORONTO:
E. F. CLARKE, CORPORATION PRINTER. 33 AND 35 ADELAIDE STREET WEST.
1887.

1987

COUNTY JUDGE'S CHAMBERS, COURT HOUSE,

TORONTO, October 24th, 1887.

His Worship W. H. Howland, Mayor, Toronto:

DEAR SIR,—I beg herewith to enclose my Report upon the investigation held by me, under a Resolution of your Council dated 28th February, relating to the Water Works Department, and containing also certain personal charges against John Venables.

Accompanying my Report you will find enclosed Reports of C. F. Hanson, acting Engineer-in-charge of the Pumping House, and of Mr. J. J. Mason, Accountant. I will forward to you as soon as it can be engrossed the very able Report of Professor Galbraith and Mr. Edwin Jones. Their draft Report was only completed Saturday last.

I have the honor to be,

Yours very truly,

JOSEPH E. McDOUGALL.

REPORT OF HIS HONOR THE COUNTY JUDGE.

TORONTO, October 24, 1887.

His Worship W. H. Howland, Esq., Mayor of Toronto:

SIR,—I have the honor herewith to submit my Report on the matters referred to me for investigation by Resolution of the Council of Toronto, dated 28th February, 1887. The Resolution is as follows:

"Ald. Hunter, seconded by Ald. Ritchie, moves that whereas it has been alleged that John H. Venables has been guilty of malfeasance, breach of trust, gross negligence and other misconduct in relation to his duties and obligations as an official of the Corporation of the City of Toronto, styled the Engineer-in-charge of the Toronto Water Works, in connection with the pumping engines, furnaces, boilers and other works and property belonging to the said Corporation, and the coal supply to the said Water Works, in that amongst other things he wilfully and negligently suffered and allowed:

"1. The engines known as the 'Worthington engines,' and the furnaces and boilers and other property belonging to the Corporation at the Water Works wharf, including the weigh house and scales, to become and remain out of repair, and some of the same to be injured and destroyed.

"2. The use of unsuitable and defective material in the construction and erection of the new engines and boilers, known as the 'Inglis & Hunter engines' and the 'Perkins steel boilers.'

"3. The contractors for the said engines and boilers to depart from the plans, drawings, profiles and specifications for the same, to the great injury of the said engines and boilers.

"4. Also that he wilfully neglected orders, and refused to obey the instructions and directions of the Committee on Water Works in relation to the testing of the said Inglis & Hunter engines, though obedience to such directions and instructions in making such test was at the time material to the acceptance or rejection of the said engines.

"5. Also that he wrongfully made a report respecting the said engines calculated to mislead, and which did in fact mislead, the said Corporation as to the character, capacity, duty and value of the said Inglis & Hunter engines.

"6. Also that he, contrary to his duty and without authority, ordered in the name of the said Corporation goods and works from the said Inglis & Hunter, in connection with their said engines, to the amount or value of $900.

"7. Also that he neglected to keep the engines, furnaces, boilers and other works connected therewith clean and in proper working order.

"8. Also that he kept an incorrect record and account of the coal received and consumed at the Water Works.

"9. Also that he issued or procured to issue certificates and caused moneys to be paid by the Corporation in respect of quantities of coal that he either knew had not been received by the said Corporation or did not know had been received by the said Corporation.

"10. Also that he generally neglected his duty, and in violation thereof refused to obey the orders and directions of the Chairman of the said Committee on Water Works and of the said Committee in connection with the management of the engines and boilers, and wilfully caused to be increased the consumption of fuel and the costs of pumping water for the said Water Works.

"And whereas, it is also alleged that the said John H. Venables and others, officers and employees of the said Corporation, have been guilty of gross negligence, breach of trust, malfeasance and other misconduct in connection with the weighing, receipt, and use of and payment for coal during the years in which the coal supply for the said Corporation was obtained from one Patrick Burns, a contractor with the said Corporation, and that the said Corporation has paid for coal which was in fact never used or supplied;

"And whereas, it is publicly charged that the evidence taken by the Police Magistrate in the late investigation respecting the supply of coal for the Water Works, disclosed an unsatisfactory condition of matters in connection, not only with the supply of coal, but also in the affairs generally of the Department of the Toronto Water Works;

"And whereas, the Auditors reported to the Council on July 19th, 1886, that there was a deficiency of $521.02, and referred to a former Report which stated that there was a deficiency of $891.29, and in the September to December quarter of 1886, of $386.98;

"And whereas, it is alleged that the said Department has been mismanaged, and that some of its officials have failed in their duty, and that the system under which the said Department has been and is worked, and supplies obtained, and moneys received and paid out, is defective, and affords facilities for fraud and misconduct, not only on the part of the officials, but also on the part of contractors and others doing business with the City in connection with the said Department;

"And whereas, the efficient working of the said Department, and the honest conduct and management of the affairs connected therewith, are matters connected with the good government of the City, and the conduct of the public business thereof: Be it therefore resolved, that it be referred to the Judge of the County Court of the County of York to investigate and enquire into the several matters and things above referred to, and into the system and conduct of that part of the public business of the City of Toronto connected

with the Water Works Department: (1) whether there has been any misconduct, breach of trust, irregularity, wilful neglect, or default, or gross carelessness on the part of the said John H. Venables, the Engineer-in-charge, or of any other officer of the said Corporation of the City of Toronto, or person in connection with the Water Works Department, or having had to do with the affairs thereof, in relation to the duties or obligations of the said John H. Venables, or of such other officer or employee, and, if so, who were the parties and in what that misconduct, breach of trust, wilful neglect or default, or gross carelessness consisted; (2) whether the system and conduct of that part of the public business of the City of Toronto connected with the Water Works Department has been or is defective, and if so, wherein the same has been or is defective, and to report thereon to this Council the result of such enquiry, and the evidence taken thereon."

Immediately after receiving the above Resolution I had a consultation with W. A. Foster, Q.C., who had been appointed to conduct the investigation on behalf of the Corporation, and I arranged to proceed with the taking of evidence as speedily as possible. On the 9th of March the investigation was opened, and from that date till the 12th of July I gave all the time at my disposal (having regard to my judicial duties) to the taking of evidence. I found on the latter date that, owing to the illness of Mr. Bigelow, counsel for Venables, it was impossible to conclude the investigation during vacation, and I, therefore, adjourned it over till the first day after vacation, namely, the 2nd day of September, and then sat daily till interrupted by the sittings of my County Court on the 13th of September. At the conclusion of my sittings, September 26th, I resumed the investigation, and finally finished the taking of evidence on the 28th of September. The stenographer, Mr. Burrows, in answer to my enquiry, told me that he would be unable to finish a complete transcript of testimony for at least a week or ten days, and I therefore postponed the hearing of argument of counsel till the 10th October inst. The hearing of these arguments occupied parts of the 10th, 11th, 12th, 14th, 15th, 17th and 18th October. During this long and tedious enquiry 121 witnesses have been examined, a large number of them having been recalled from time to time to give testimony upon various points. This was unavoidable owing to the wide scope of the investigation. The evidence written out covers 2,443 pages, and contains about 7,500 folios, while 218 exhibits have been fyled.

THE RATING AND RECEIVING DEPARTMENTS.

1. The first branch which came under my observation was the Receiving Department of the Water Works. Manifestly it is of the utmost importance that this branch of the service should be conducted on the soundest business principles; the annual revenue exceeds $300,000, and the collection of this large amount, the dealing with over 28,000 accounts, the making out of proper bills and the entering of the respective debits and credits demand a thorough system.

2. I found that prior to March 1, 1887, there had been no system that could be dignified by that name. The Department, nominally under the control

of the Superintendent, was really in the hands of the late Secretary of the Board, a Mr. Morriss. Mr. Morriss was also head receiver. He kept the cash-book, balanced his cash once in three months – that is, if the books would balance—he received and paid all moneys over to the City Treasurer, taking his receipt for the same. Mr. Hamilton, the Superintendent, admits that he found fault with the system prevailing at the date of his appointment in 188 . Yet he says that, although personally responsible for the the working of the system and for the proper handling of the whole revenue, he was unable to effect any change in the system. He says that the obstacle in the way of reform was the Secretary, Mr. Morriss. This gentleman, it appears, was opposed to any changes. Mr. Hamilton says that both he and Morriss thoroughly agreed that the then system was defective and incapable of a correct audit, yet Mr. Hamilton could not get the system changed, Morriss saying, when appealed to to consent to needed improvements, that he had changed the system too often and he would not change it any more; and accordingly Mr. Morriss.—who evidently ought to have been Superintendent—carried his point, and the system was not changed until some time after Mr. Morriss had retired from the Department and Canada. Shortly before Mr. Morriss left the Department a discrepancy of $550 had been accidentally discovered in his cash. The Department were fortunate enough to have this amount made good by Mr. Morriss' private cheque. The amount of this discrepancy, which it appears was cash received and not accounted for, remained in Mr. Morriss' hands for over a year before it was discovered. There had, therefore, evidently been no correct balance of his cash for over a year prior to the discovery, or this item would have come to light before. Comment is needless upon the defects of such a system as the foregoing.

3. There are two branches of the Receiving Department, the Receiving and the Rating branch. It appears from the evidence that frequently officers of the Rating Department acted as receivers. This, as the auditors point out, is a radically wrong and vicious system. The officer who prepared the account should not receive the money; the officer who received the money should not prepare the account. Each branch should be entirely distinct with a separate set of books as far as possible. The Receiving branch should have nothing to do with the making out of accounts. Their sole duty should be to receive the money for the account returned by the Rating branch, to properly enter the same in appropriate books, and pay over the amount of their receipts daily to the City Treasurer. The Rating branch ought to make out all bills and render the same, and if there be new consumers, strike the rate to be charged them, and generally to alter, vary and correct and keep track of the account of every consumer; and finally, quarterly, or half-yearly, furnish to the Receiving Department a detailed statement of the moneys to be collected. Then the amount collected plus arrears should equal the amount charged to consumers, and one set of books should balance the other.

4. The Auditors, it appears, reported on several occasions that there were differences in the accounts of the Water Works Receiving Department

which they could not get explanations for, that from the system in force a proper audit was difficult, if not impossible, and that the accounts were in an unsatisfactory state and unfit for audit. Nothing was done to remedy it by the Superintendent, the Water Works Committee or the Council, until just as this investigation was commencing, when certain changes were made and the Receiving Department taken out of Mr. Hamilton's hands and placed under the supervision of the City Treasurer, Mr. Harman.

5. As the dealing with this question of accounts, and the bookkeeping connected therewith, was a matter requiring professional skill and knowledge, I determined to secure the assistance of some reliable expert to aid me in arriving at proper conclusions. I communicated with and secured the co-operation of Mr. J. J. Mason, of Hamilton, ex-Mayor of that City, and also an accountant of Dominion reputation.

6. As to the Receiving and Rating branches, after careful consideration and full consultation with Mr. Mason, I beg to adopt the recommendations made by him in his Report to me. They are the following:

(*a*) That the Rating and Receiving Departments should be absolutely and entirely separate, the staff of one having nothing whatever to do with the other.

(*b*) That the cash received by the receivers should be day by day checked and handed over to the cashier or Treasurer.

(*c*) That the street cash books should be posted daily into the street ledgers by clerks not being receivers; or, in other words, that the receivers should not post and check their own receipts.

(*d*) That the casual or intermediate charges and changes should be entered by the staff of the Rating Department in the street ledgers, and not by the clerks in the Receiving Department.

(*e*) That, if possible, the books of the Receiving Department should be closed and balanced prompt at the end of the first month of the quarter, the balance still due being at once treated as arrears.

(*f*) That, if possible, the collection should be made half-yearly, instead of quarterly, whereby the working of the Department and its audit will be rendered much easier. There could then be no excuse "that the work of one quarter was forever treading on the heels of the succeeding quarter."

7. I very strongly urge the adoption of the last of the above recommendations. It will reduce by one-half the bookkeeping of the Department. Instead of making out 28,000 accounts four times a year and carrying them through a set of books, they would be made out twice only. The Department could do the work with a smaller staff; the work of each half-year would be completely closed before the new half-year commenced; whereas, if the collections are quarterly, it is found that with such an enormous number of accounts to deal with, the work of one quarter follows so closely on the heels of the next it is impossible to prevent overlapping and con-

fusion. A careful audit is also difficult, owing to the short time that the books can be spared from actual use.

8. I would also recommend that security should be taken from all officials handling cash. It is done in all banks and financial establishments, and I think the City ought to protect itself as carefully as such institutions.

9. In connection with the Revenue and Rating Department, I would strongly recommend a thorough system of house-to-house inspection of services. I am satisfied that millions of gallons of water are wasted daily by reason of defective plumbing and unchecked and improper use by consumers. The water famine which occurred this last summer was largely caused by unnecessary waste. Inspection heretofore has been a farce. House services in many parts of the City have not been inspected for years. Inspection to be effective must be frequent. Washers on taps will barely last three months exposed to our high water pressure. To see that these are promptly replaced requires inspection once a quarter.

9. Another radical change which I strongly recommend is to compel all plumbers to take out a City license. Compel them to get a permit from the Water Works Department before they start to fit up a service in a house, and make them fyle a report of the work done when finished, so that the same may be duly inspected before the water is turned on. The plumber should also give a bond to the City to be answerable for all defective work and materials. Bad plumbing is responsible for nearly all of our sanitary troubles, and much of the enormous silent waste of water in this City. A pecuniary liability on the part of the plumbers of this City for bad work and materials—and the liability sharply enforced—will, in my opinion, work a revolution little dreamed of. Inspectors on their rounds should promptly turn the water off on the street where they find any defective plumbing and taps out of order. The water should only be turned on again after repairs have been made by a licensed plumber, and the work again inspected and passed by the Department's own officer. A few months' practice of the sharp discipline such as I indicate, would cause the repair or renewal of half the plumbing in the City, and the quantity of water used, in my opinion, would be reduced at least by thirty to fifty per cent.

10. I am further of opinion that some active, shrewd official should be put in charge of the receiving, rating and inspecting staff as chief clerk, whose authority should be unquestioned, and who should be held responsible for the proper working of the Department. He should be responsible only to the Superintendent, and might, for lack of a better name, be called "The Accountant." It is the sound principle adopted by every merchant doing a large business in the City that there should be one man at the head of every branch of it, and every one of these responsible to him as the head of all. At present there is no responsible head of the Department except the Superintendent, and his duties are so numerous that he can give but little time or personal supervision to this important branch of the service.

11. The Auditors, in their evidence before me, stated the various difficulties they had experienced in endeavoring to audit the books of the Department —and differences they had found in the cash and several items, even down to April last—but as the whole Receiving branch is now under Mr. Harman's control, and has been removed from Mr. Hamilton's jurisdiction, I will not, in view of the radical reconstruction which will doubtless take place under the new regime of the Treasurer, discuss further the details of these unsatisfactory audits.

THE PRESS HOUSE.

12. The next branch of the service which I propose to deal with is the Press House, where stock in hand and all Water Works material and supplies are supposed to be kept, and where all additions to, or diminutions from stock are supposed to be carefully recorded. According to the storekeeper, Mr. Thomas R. Skippon, his books are never audited. He takes stock himself once a year, with the assistance of a couple of clerks of the Water Works Department, who know little or nothing, as Mr. Skippon admits, of the nature or value of the stores being enumerated. All goods are paid for on Mr. Skippon's certificate that they have come into store. Mr. Skippon frankly admitted that there was little or no system in the conduct of the Press House business except such as had been devised by himself. His books are never examined, and when I asked him if the Department had any means of checking or detecting any dishonesty on his part should he prove faithless, as, for instance, certifying for goods never received by him or otherwise colluding with contractors to defraud the City, he said quite frankly he did not think the Department, under the present system, could discover such intromissions. I need hardly say that there was no shadow of suspicion that Mr. Skippon's performance of his duties had not always been honest and straightforward, but, like an honest man, he stated—what appears to be the fact—that the method of doing business at the Press House was highly unsatisfactory, and he himself would be glad to see a better system adopted.

13. The storekeeper should keep a stock book and daily journal, or blotter, showing the goods issued and to whom. This book should be made up weekly and the quantities carried into the stock book at least once a month, deducting their stock in hand, and the stock book thus balanced. All new stock coming in should be entered in the stock book from time to time as received. No article should be delivered out without a written order from the Superintendent. I think the foremen should send in all their requisitions for supplies to the Superintendent. He should go through and countersign them, and he would know each day what and where all supplies were being used. To facilitate the despatch of business all these requisitions might be left at the Press House, and it ought to be the duty of the Superintendent to call first at the Press House before going to his office. There should be one man responsible directly for the expenditure of every cent of money and every ounce of material. I think a system is in the highest degree defective which allows any ward foreman or outside foreman

to be able, without the knowledge of the Superintendent and on their own mere motion, to order from the Press House and receive thousands of dollars of material for alleged user in different parts of the City. The storekeeper should have the Superintendent's written order for the disposal of every article not found in his stock when his books are balanced or audited. He should also have the Superintendent's written order for every article purchased by him and added to stock. When articles are wanted to be added to stock, whether they are such as are being supplied by contract, or to be purchased in open market, the storekeeper ought to requisition the Superintendent for them, and get his written order to procure them. The storekeeper's books should be carefully audited, and I think stock should be taken at least twice a year.

14. I will conclude my Report as to the Press House by suggesting that it would be wise if the Press House was placed at some point near the engine-house, so that the surplus supplies for the pumping-house could also be kept in store, and delivered out conveniently from time to time as required, on the written order of the Superintendent. At the present time it will be well to mention that the value of the goods and stock of various kinds, including water pipes, passing through the storkeeper's hands, exceeds $60,000 per annum. You can better judge from a knowledge of this fact the great importance of a proper system of dealing with the items of so large an expenditure.

ENGINE AND PUMPING HOUSE.

15. The next and most difficult part of my duty in reporting to you is to deal with the mass of testimony laid before me relating to the condition and management of the pumping house, and to the grave personal charges preferred against Mr. John Venables, the engineer in charge. Before entering upon the consideration of this part of the case, I had better state what steps I have taken to get at reliable data as to the position of affairs at the engine house, outside of the verbal testimony of the various servants and officials constituting the staff of this branch. Early in the investigation, and after consultation with the Investigation Committee, I determined that it was highly important to have the new Inglis & Hunter engine carefully examined by some independent and unprejudiced experts. I had two objects in view: First, to ascertain by a practical test the actual pumping capacity and duty of the engine, so that we might discover if the engine would answer the guarantee given to the City by its builders, Inglis & Hunter, and, as a part of the result, to discover if the former tests made by the City Engineer and Mr. Hamilton could be relied upon as accurate and trustworthy; and second, to have the design and construction of the engine thoroughly examined into and any defects or weaknesses of its original construction pointed out. To this end I named as experts the following three gentlemen: Professor Galbraith, of the School of Practical Science; Mr. Edwin Jones, of Chatham, mechanical engineer and machinist of undoubted skill and reputation, and Mr. C. F. Hanson, of London, for many years foreman of the shops of the Detroit, Grand Haven & Milwaukee Railway, and late for

the Great Western Division of the Grand Trunk Railway. As the latter gentleman had a long experience in managing large establishments, I placed him, with the approval of the Committee, in temporary charge of the engine house and the existing staff. He continued to act as engineer in charge, under my directions, until the 30th of September. The experts commenced their duties on the 28th day of May. They overhauled and examined the Inglis & Hunter engine as carefully as possible, but, within a few weeks after their appointment, it became manifest that the enormous consumption of water by the citizens, occasioned by the excessively hot weather in June and July, would render it impracticable to safely make a careful duty and capacity test of the engine. Such a test might be made later in the fall when the reservoir would be full and the other engines could safely be stopped with the object of a test. In view of this conclusion, in which the experts concurred, Prof. Galbraith and Mr. Jones gave up their charge in July without having made a formal capacity test. I, however, directed Mr. Hanson to remain as acting engineer until further orders, and on September 30th I informed the Water Works Committee, through Mr. Boustead, their Chairman, that I had concluded the taking of evidence and desired them to relieve me and to assume control again of the pumping house themselves. They at once complied with my request.

16. Certain startling facts have been established as the result of the labors of these experts.

(*a*) The Inglis & Hunter engine is incapable of doing her guaranteed duty.

(*b*) The official tests, alleged to have been made before accepting the engine from the contractors, are unreliable if not totally fallacious.

(*c*) There is the strongest reason to suppose that a gross fraud was perpetrated before or during the test, by tampering with the pressure gauges, thereby rendering the tests utterly valueless and misleading.

(*d*) Both the Worthington engines are in a poor state of repair and need an immediate overhauling, and one, if not both of them, are liable to give out at any time, thus leaving the City to depend for its water upon the new engine, which was idle and helpless from breakdowns for 96 days during the year 1886, and 104 days during the year 1887 up to October 13th.

(*e*) That the annual reports are also misleading and unreliable in the information they purport to furnish.

17. The Inglis & Hunter engine, in the opinion of all the experts (including Mr. Venables himself, as appears by the evidence), cannot be safely worked to pump more than ten millions to ten millions five hundred thousand gallons of water per diem. She was purchased as able to perform an easy duty of twelve million gallons. At the first official test made by him, Mr. Sproatt reported the engine and pumps as performing the guaranteed duty, and pumping the guaranteed capacity. The duty was to equal at least seventy million foot pounds to one hundred pounds of coal, and the capacity, as I have said, twelve million gallons per twenty four hours. At the second test,

made by Mr. Hamilton a few weeks later, he reports obtaining the same results, and the engines and pumps, according to him, answering all requirements of the contract. When the experts I appointed overhauled the Inglis & Hunter engine they found the pressure gauge out of order, and, upon taking it to Mr. Morrison, the brass founder, for repair, the workman who had made it, a Mr. Oliver, found the gauge eighteen pounds out in registering. That is, it recorded a pressure eighteen pounds per square inch higher than the fact. Now, the evidence of Mr. Oliver, the gauge maker, is to the effect that the gauge had the appearance of having been tampered with, and he explained his reasons for saying so, and showed how simple it was to remove the dial to alter the gauge. Mr. Sproatt says before commencing his test he thinks Mr. Venables tested the gauges. At any rate, he was assured that the gauges had been tested, and he himself did nothing towards testing their accuracy. Mr. Hamilton says he asked Venables if he had tested the gauges, and he says Venables told him he had tested them and that they were correct. Venables says that he did not test the gauges, but he may have told both Hamilton and Sproatt that they were all right, but that if he said so he relied upon what Martin, of Cleveland, and Messrs. Inglis & Hunter told him, as, of his own knowledge he could not say whether they were right or wrong. The gauges are supposed to work satisfactorily for two years. Mr. Hamilton says that when he tested the engines he took a recording gauge of his own down to the engine house, and placed it on the air vessel of the Inglis & Hunter engine. He says it registered a difference of eight or nine pounds less pressure than the pressure gauge on the engine, but he says he accounted for this by the difference of their local situations, one being farther away from the engine than the other. He says he did not have his own gauge tested before making the test, and the fact that there was such a wide difference as eight or nine pounds indicated between the two gauges did not lead him to have either of them tested afterwards, and, strange to say, in figuring up the performance of the engine the pressure recorded by the gauge now suspected of being eighteen pounds too high, and not that recorded by Mr. Hamilton's gauge, was used as the factor for determining the duty of the engine. Now, let us see what this alleged difference in the gauge means. According to Mr. Hamilton, the duty performed, taking the pressure indicated by the gauge as correct, was seventy-five million foot pounds. If the gauge registered eighteen pounds too much, and this error is corrected in the calculation, the test would indicate a duty of sixty-four million foot pounds only, or six million foot pounds below the guaranteed duty, and the engine ought not to have been accepted. I wish to report at this point that I deem both Mr. Sproatt and Mr. Hamilton guilty of gross and culpable carelessness in not personally seeing that the pressure gauges were specially tested before and immediately after the official test of the engines, to ascertain to a certainty the correctness of these tell-tale instruments, whose registrations were relied on chiefly when calculating the performance of the engines and pumps. In consequence of their neglect to verify the accuracy of these gauges, I consider the test of the engines made by them as utterly unreli-

able, and, as it appears in the case of Mr. Hamilton's test, the large difference between the two gauges was actually indicated, I consider his test of the engines not only unreliable but totally fallacious. There is thus a very strong case of circumstantial evidence to support the theory that the pressure gauge had been tampered with by someone before the tests were made by the City officials. The motive would be to secure beyond doubt an apparent performance of the duty and capacity on the part of the engines, and so secure their acceptance and payment of their price. The subsequent history of the Inglis & Hunter engine, and its utter inability to perform the guaranteed duty, supports the belief that the engine and pumps never did the duty contracted for in fact, and the apparent performance was only secured by means of fraud and chicanery. Before leaving this branch of the case I have, however, to report that the evidence shows that the pressure gauges of the two Worthington engines were also utterly worthless, not having been cleaned or regulated or tested for between eight and ten years. One registered fourteen pounds too high, and the other eighteen pounds too high.

18. By the accompanying Report of Engineer Hanson it will be seen that the two Worthington engines are in a very unsatisfactory condition and in urgent need of thorough repair.

19. The annual reports of the Water Works Department, issued by the Superintendent, are unreliable and misleading. A book called an "Engine Record Book" is kept at the Engine House. It purports to show, amongst other things, the water pumped and coal consumed from day to day. I have caused a table to be prepared showing the coal consumed, according to the Engine Record Book, for some four or five years past, and comparing it with the coal bought and paid for, the result is startling. The City in five years has bought and paid for two thousand four hundred and forty-two tons more coal than the engineer, Mr. Venables, reports from week to week he has consumed under his boilers. The figures published in the annual reports of the duty performed and the water pumped, as made up in the office from such contradictory and unreliable data as I have mentioned in the preceding paragraphs, will at once show that they contain no reliable or accurate information for the Council or public.

20. I therefore find, on the evidence before me, that the Inglis & Hunter engine, bought and paid for by the City, does not perform the guaranteed duty and is not of the guaranteed capacity. I find that she has been idle in the year 1886, 96 days, and the year 1887, to October 13, 104 days, all such idleness being due to breakdowns arising chiefly from her bad design, ill proportions and defective adjustment of parts and gear.

21. I have also to report that in my opinion it will be a matter of great risk and danger to dismantle either of the Worthington engines, with the view of overhauling the same, depending meanwhile on the Inglis & Hunter engine to keep up with either of the Worthington engines the daily supply of water. It ought to be well considered in the Council whether some additional engines should not at once be purchased.

22. I beg to forward the able Report of Professor Galbraith and Mr. Edwin Jones as to repairs and alterations to be made to the Inglis and Hunter engine. These repairs, if made, may improve in some measure her stability and working powers. In the light of the evidence taken at this inquiry I beg to concur in their recommendations.

PERSONAL CHARGES AGAINST VENABLES.

23. In regard to the specific charges against the Engineer, Mr. Venables, I beg to report as follows: I find that as to the first charge the only matter proved to my satisfaction is that Venables neglected to have the flues of the boilers under his charge properly cleaned or kept clean, as directed by the Chairman of the Water Works Committee and his Superintendent, thereby causing injury to the flues of the said boilers and necessitating repairs to the said flues and increasing the consumption of fuel.

24. I find the second charge not proved.

25. I find the third charge proved to this extent: That the said Venables was aware, in the construction of the Perkins steel boilers, that the specifications, drawn by himself, called for drilling the rivet holes in the boiler plates; yet he saw the contractor causing the rivet holes to be punched, instead of drilled, and did not report the same to the Superintendent, as was his duty.

26. I find the fourth charge not proved.

27. I find the fifth charge proved by Venables' reports of May 9th, 1886, July 6th, and July 8th, 1886, which reports I consider misleading.

28. I find the sixth charge not proved.

29. I find the seventh charge not proved, except as to the flues of the boilers, as mentioned in my finding under the first charge.

30. I find the tenth charge not proved, except as mentioned in my finding on the first charge.

31. I find under the general language used by the Council towards the end of the Resolution forwarded to me that the said Venables did neglect his duty to the Corporation in the following particulars:

(*a*) He failed to report to the Superintendent the drunkenness of the men at the engine house. I find that while Venables had charge there was a great deal of drinking amongst the firemen, and that some of the assistant engineers were implicated also in this offence. These breaches of duty were not reported to the Superintendent or Committee, except in the case of one man, whom the Engineer suspended. It is true that the Committee reinstated this man, notwithstanding his offence. Although the Committee took this untoward action, I think it was still the duty of Venables to report all cases of drunkenness promptly, and I find he neglected to do so.

(*b*) I find that he was careless and neglectful in not providing some system for the economical use of lubricants at the engine-house. I find that there

was no system in giving out or using oils at the engine-house, by which the consumption could be seen either by the Superintendent or Committee in any other way than by adding up the amount of the bills rendered for oil supplied. In every well-regulated engine-house that I have visited the engine record book shows the oil used from week to week, and forms a prominent feature in the engineer's weekly report. The Buffalo four engines, pumping thirty-five million of gallons per diem, used about $800 worth of oil per annum. The oil purchased in 1886 for our pumping-house, as appears in the Report, was $' 00 worth used on three engines pumping only about fourteen million gallons per diem.

(*c*) I find Venables guilty of gross and culpable carelessness and neglect of duty, in stating to Mr. Sproatt at the time of the test of the Inglis & Hunter engine that the pressure gauges were all right, and in telling Mr. Hamilton that he had tested them when he had not. This does not relieve Mr. Sproatt or Mr. Hamilton of their responsibility in the premises, for they ought to have seen to this matter personally.

(*d*) I find that Venables kept untrue records in his engine record book, that he weekly certified to the correctness of each page of the entries in said book, well knowing as to the coal entries that they were estimates only, and no' the actual weights, as such record purported to show, thus deceiving and misleading the Committee.

32. I now propose to deal with the charges 8 and 9, the most serious against Venables, namely: That he kept an incorrect record of the coal received, and issued certificates for coal alleged to have been received which he knew had not been received or did not know had been received at the pumping-house.

33. There was kept at the pumping-house a book called the coal book. It was the official record of the coal received by the City for the Water Works. It purported to give the name of each vessel discharging at the pumping-house, the date of its arrival, date of unloading, contract under which the coal was delivered, the weight, cart load by cart load, of each cargo as received, the weight, cart load by cart load, of yard deliveries distinguished from vessel loads. A duplicate of this book was kept at the office at the City Hall, and the original was sent from time to time to the office to be copied. This book was kept by Venables, and until the years 1883, 1884, and 1885, Venables had invariably certified on the face of the book, both in the book itself and the duplicate at the office, that they were correct. The practice then ceased of certifying, though Venables still certified to progress certificates to the coal contractor, and the book itself, as kept, was the basis upon which the Superintendent would certify to the coal accounts rendered by the contractors. All coal was paid for by the City weights as recorded in this coal book. This book was in Venables' charge, and was kept by him, although sometimes entries would be made in it with his knowledge and assent by his own employees, sent by him to weigh coal, but by far the larger number of entries in the book are in Venables' own

handwriting. Venables, in his evidence, states that it was his duty to see that the men weighing the coal did their duty. It was by the record in this book that Burns was paid. The charge made is that a number of false and fraudulent entries were made in this book of coal never received by the City, and that Burns, the contractor, was paid for the coal so fraudulently entered, though, as a fact, the same was never delivered or received at the pumping-house. The coal book shows in 1883 that Burns delivered by certain named vessels 5,876 tons to the City. By the Harbor Master returns and Customs returns and Burns' books it appears that harbor dues, duty, and freight was paid on 5,441 tons only by these same vessels, the difference, 435 tons, it is charged, represents the sum of the false entries for that year. In 1884 the coal book shows 5,515 tons similarly delivered by vessels. The Harbor Master and Customs returns and Burns' book show the harbor dues, duty and freight to be paid on 5,430 tons only, the difference being 85 tons in this year, is also alleged to be fraudulent. Again, there appear on pages 122 to 126 of the coal book entries of 417 tons of coal. These are charged as all being fraudulent entries, and they are all in Venables' handwriting. In January, 1885, a number of deliveries are entered up as having taken place from Burns' yard. At one time tickets were held by the Department as vouchers for these deliveries. After an audit, which failed to explain discrepancies between the coal book kept by Venables and the tickets produced in support of the alleged deliveries, all the tickets relating to the coal weighed by Venables disappeared mysteriously from the Water Works office and have never since been found. It is charged that a series of twenty-five tickets in all, representing coal to the extent of eighty-six tons, were false and fraudulent, and that such coal as there represented was never delivered. It is also charged that the various entries were made by Venables in the coal book from time to time after the book had been returned from the office, where it had been sent to be copied, the object of which entries was to cover up these various alleged fraudulent transactions.

34. I have most carefully weighed all the evidence adduced upon these various charges, and in support of the alleged fraudulent entries by Venables in the coal book, and I have examined every circumstance which might offer any explanation in favor of the accused, or shift the responsibility from his shoulders to those of any other official; I regret to say that I am compelled to report to you that, in my opinion, the charges have been sustained by testimony that admits of no doubt to my mind. The evidence establishes satisfactorily, in my opinion, that the coal account of the Water Works Department for the years 1883, 1884, and the months of January and February, 1885, as kept in the City coal book by John Venables, and those under his care and direction, has been deliberately falsified, and that fraudulent entries of large quantities of coal never delivered to the City had been made in this coal book, and that very many of the entries, which have been proved to my satisfaction to be fraudulent are in the handwriting of John Venable. I also beg to report that, in my opinion, these entries were made

by the person making them knowingly, and for the purpose of defrauding the City.

35. The actual amount of these frauds will never be known, but the evidence shows that the City has paid for over 1,000 tons of coal in 1883, 1884 and 1885 not one pound of which was ever received by the City. I need not say that it has been one of the most painful and disagreeable duties I have ever been called upon to discharge to be compelled to report to the Mayor and Council of Toronto the conclusion above stated by me. I would gladly have availed myself of any reasonable ground for arriving at a different opinion. I have found nothing, however, in the evidence, after the most careful and anxious consideration, or explanations made by Venables through his counsel, which warrants any modification of these findings upon these grave personal charges against Mr. Venables.

36. The matter of these fraudulent coal transactions is of so much importance that I strongly recommend that all the evidence, and exhibits relating thereto, be carefully preserved and placed in some secure custody so that they may be forthcoming should occasion arise for their being consulted again.

37. I have to report that, in my opinion, Superintendent Hamilton does not appear to exercise that control over his department that a Superintendent should. The instance I have mentioned in the earlier part of my Report, as to his failure to effect changes in the Receiving Department, illustrates my meaning. It also appears from the evidence that he does not possess that control and influence at the pumping-house that I think a Superintendent ought to exercise and possess. He did not secure or enforce at the pumping-house obedience to his orders and those of the Committee. How much of this inaction is due to the system which has heretofore prevailed, or how much to Mr. Hamilton's somewhat temporizing disposition, I do not care to examine into. One thing I do deduce from the evidence, as to the management of the whole Department, is that until just before this investigation every official at the head of any branch of the Department seemed to consider himself master of the situation, as far as his own branch of the service was concerned, and Mr. Hamilton's suggestions of changes or improvements were either opposed and thwarted, or a point blank refusal was given to carry them out. I find no steps taken either by the Committee or Superintendent to punish promptly many cases of insubordination and disobedience of orders.

38. One cause of much of the difficulty is the manner in which the employees are engaged by the Department. I find thirty-five men are employed by the year, and are on what is known as the Salary By-law. I find about forty-three men are hired and paid by the week or month. These latter, I presume, are directly under the control of the Superintendent and Committee, but the former, I understand, cannot be removed from their situations except by resolution of the Council. The result of this is that many of the employees of the Department have apparently more influence in the

Council than either Mr. Hamilton or the Water Works Committee, and any attempt to remove them, even for grave causes, frequently results in a dismal failure; and the "persecuted" employee is reinstated over the Superintendent's head, and is ordered to be paid for time under suspension. An inspector recently suspended for drunkenness, protracted to the extent of a several days' spree, only failed by one vote in reversing the action of the Superintendent and being placed at work in defiance of discipline, subordination and good example.

39. I recommend that no employes, except the Superintendent and engineer at the pumping house, should be placed on the so-called Salary By-law. All other employees should be selected and appointed by the Superintendent and Engineer. They should hold their places during their pleasure only, and the Superintendent and engineer should have the right to suspend and dismiss in a summary way any employee not performing his duty. The engineer at the pumping house, especially, should have the power to employ all his own assistant engineers, firemen and laborers. He should be held responsible for all that transpires at the engine house, and should have absolute control of all the men under him, and his power to peremptorily discharge should be without appeal. It is only by thus throwing the entire responsibility upon one man at the pumping house, and holding him to rigid account for all that occurs there, that we can avoid a constant repetition of many of the evils of grave import disclosed by this inquiry. These comments are equally applicable to the other branches of the Water Works Department.

40. The foregoing paragraphs of my Report lead me to express my opinion on another phase of the question. This inquiry has disclosed incompetency, dishonesty, extravagant management, utter lack of check and entire absence of system in every branch of the Department—in the Receiving, Rating and Inspecting branches, in the press house and in the pumping house. The changes suggested, if carried out, mean a revolution. Now, there is one additional change which I strongly and emphatically recommend, and that is, that the whole control of the Water Works Department should be placed in the hands of a competent commission. The present inquiry has developed the fact that the best meaning Alderman, elected to the Council and placed upon the Water Works Committee, becomes a mere cipher in effecting reforms. Before he can educate himself, and acquire the requisite knowledge to suggest changes, he finds his term expired; and very possibly if he has proved himself inconveniently inquisitive into any branch of the service, he falls a victim to society and other occult influences wielded by wire-pullers, ward politicians and alarmed officials. His usefulness as an Alderman is found to be gone and the electors will probably be induced to say so too. It has been only after a three years' fight, maintained vigorously by ex-Mayor Manning, Ald. Walker, Hunter, Hall, Millichamp, Boustead and other members of the present Water Works Committee, that this question of the rottenness of the system and the incompetency and dishonesty of some of the officials has been brought to a head. Every obstacle

has been thrown in the way of the inquiry by some officials. Papers and documents have disappeared. Seen a few days before the investigation, they are not forthcoming when called for. An important book disappears from the engine house. A window has to be broken open to get at it. It is said this burglary was committed by an official, but the inculpated individual does not rise to explain, and the book never sees light again. A lock on a desk is broken off, and books stored in the desk cannot be found. Fortunately in this case the books are found a day or two later, after it has been delicately insinuated that an investigation before the Police Magistrate may disclose the burglars and the whereabouts of the plunder. At a large expense, and in spite of official dilatoriness, indifference, and active opposition, in spite of malicious and desperate efforts to excite public sentiment against the inquiry proceeding, the history of the mismanagement of the Water Works Department for three or four years past has nevertheless, been laid before the public.

41. I beg respectfully to report that, in my opinion, the result of this inquiry has demonstrated beyond question that a Committee of the Council, however conscientious and well-meaning, is utterly unfit to control the affairs of so important a Department as this has grown to be. The short tenure of office of an Alderman, the manner in which these are selected from the body of the Council, the constant annual change in the personnel of the Committee, the impossibility of acquiring detailed knowledge or experience worth anything in so short a time as a year, or even two years, all tend to one result—instead of the Committee managing the Water Works, members of the Committee are glad to depend upon those they consider experienced officers; and the officers of the Department, as has been pretty conclusively shown in this inquiry, manage the Committee. Any Alderman who objects, and insists upon a more active voice in affairs, is pronounced a crank by the officials, and probably also by a majority of his fellow Committeemen. Government by Committee, I fear, means inefficiency, quarrelling, log-rolling, the dominance of private over public interests, and, I fear, in some cases corruption. Executive functions are best exercised by a few in number.

42. I should, therefore, venture to suggest that it would be a wise movement to secure legislation to place the Water Works Department under the management of a commission of three gentlemen appointed for a term of, say, five or six years. As to the mode of their appointment, I was much impressed with the system prevailing at Detroit and Buffalo. The commissioners there are nominated by the Mayor and confirmed by the Council, holding office for six years. This method of management in Buffalo has existed there since 1872 with, it is said, the most gratifying results to the public. The Department was taken out of the hands of a Committee of the Council and handed over to a commission, I am informed, owing to a somewhat similar experience by the citizens to that we are now passing through.

43. The rapid growth of our City and the necessity for making important extensions of the Water Works system, and procuring additional dumping

machinery in the near future, all point, in my opinion, to the wisdom of placing the Water Works Department under a commission of practical business men who can devote a considerable portion of their time to their duties, and who will hold office long enough to acquire a personal knowledge of every detail of the wants and requirements of the system. The Commissioners should be men of reputation, position and ability, whose business skill and instincts would secure the selection of competent officials to conduct the practical work of the Department. There is no lack of material amongst the citizens of Toronto from whom the Mayor could make his nominations.

44. In conclusion, I desire to express my indebtedness to the learned counsel, Mr. Foster, Q.C., for the assistance he has afforded me, and for his care in sifting the enormous mass of testimony before calling his witnesses-a task which infinitely shortened my own labors. Mr. F. A. Drake, student, at-law, was also of great service to both Mr. Foster and myself, and most useful in searching and unearthing documents relating to the enquiry from the various City Departments and unlooked for hiding-places. The Assistant City Clerk, Mr. Littlejohn, has been invaluable in preserving, marking and arranging the mass of exhibits fyled, and has saved us many hours of valuable time by being able to place his finger in an instant upon any paper or book amongst the hundreds confided to him whenever the same was called for to be placed in a witness' hands. Mr. Burrows has made a faithful and intelligent transcript of the evidence—a task, considering the technical character of much of the testimony, few stenographers would have so successfully accomplished. All these gentlemen have discharged their various duties with signal ability and energy. I could not, in justice to them, conclude my Report without making special mention of the valuable aid I have received from them.

All of which is respectfully submitted.

JOSEPH E. McDOUGALL,
Judge, County Court, York.

REPORT OF J. J. MASON, ESQ.

To His Honour Judge McDougall, Toronto:

SIR,—In compliance with your request, I have examined the system in force in the Rating and Revenue Departments of the Toronto Water Works, and with your concurrence I examined the systems obtaining in Buffalo and Detroit, in order that I might have the benefit of the experience of these cities in forming a general opinion upon the subject.

In pursuing my investigations in Buffalo and Detroit, and also in Toronto, I had the cordial co-operation and assistance of all the officials, and had every opportunity of watching and examining the daily routine in all its branches.

TORONTO WATER WORKS.

I find that the mode of obtaining water in the first place is somewhat the same as in the other places visited.

The plumber of the Department gets a copy of the application, and makes a return of the work done and the material used.

The inspector checks the particulars and certifies to the rating, and it is then entered on the rating ledger, and a bill made out. The accounts with new takers are kept in the Rating Department till the close of the quarter, the new taker obtaining his bill from the Rating Department and paying it to a receiver in the Receiving Department, who makes an original entry in his book corresponding with the entry in the book in the Rating Department.

The separate assessments or ratings number about 28,000, the bills being made out quarterly, entered on the street ledgers, and delivered by seven inspectors (one for each district), the street ledgers being handed over to the Receiving Department, with an abstract of the total amount to be collected.

There are four receivers in the Receiving Department, the books now in use, for they have undergone changes during the past few years, being:

1. Street ledgers, or rating books.
2. Rough cash books, or cash blotters.
3. Street cash books.
4. Street daily cash abstract books.
5. General cash book.

When a bill is brought in and paid it is stamped "Paid." The counterfoil is also stamped, torn off, and kept, the amount only being entered on busy days, and subsequently transferred to the street cash book or journal, and from there to the street ledger.

It occurred to me that in using the street cash journals as original books of entry, time would be lost at the most important period, that is when payments for the quarter were crowding in; but I was assured that this was not the case, and, if so, it appeared to me that the rough cash books might be dispensed with as being practically useless, the remaining books being quite sufficient to complete the system.

I do not like the plan of keeping counterfoils to be entered up at a later day in original books of entry, but if the amounts are entered at the time of payment in the street cash journal without involving unnecessary loss of time to the payers, then I can see that the plan possesses many advantages. The amounts are more easily added, are much more easily posted to and checked with the street ledgers, and any errors in posting are more easily detected.

As the result of my examination of the systems in force in the three cities named, I am led to the conclusion:

1. That the Rating and Receiving Departments should be absolutely and entirely separate, the staff of the one having nothing whatever to do with the other.

2. That the cash received by the receivers should be day by day checked, and handed over to the cashier or treasurer.

3. That the street cash books should be posted daily into the street ledgers by clerks, not being receivers, or in other words that the receivers should not post and check their own receipts.

4. That the casual or intermediate rating charges and changes should be entered by the staff of the Rating Department in the street ledgers, and not by the clerks in the Receiving Department.

5. That, if possible, the books of the Receiving Department should be closed and balanced promptly at the end of the first month of the quarter, the balances still due being at once treated as arrears.

6. That, if possible, the collections should be made half-yearly instead of quarterly, whereby the working of the Department and its audit would be rendered much easier. There could then be no excuse "that the work of one quarter was forever treading on the heels of the succeeding quarter."

I think that if the suggestions I have made are as far as possible carried out, the City Auditors will be enabled without unnecessary labor to audit periodically the books of the Water Works Department, and I am of opinion that their duty consists not so much in balancing the books and accounts as in seeing that they have been properly balanced by the officials of the Department.

I have said nothing as to the question of the security to be furnished by the officials; this is a matter of local regulation. That security of some kind should be furnished is, I think, indispensable; but whether by the

head of the Department alone, or by the individual employees, must be to a certain extent regulated by the system in force.

I append for information notes taken by me on my visits to Buffalo and Detroit as a matter of information, and with the view that they may be possibly of some use to the Water Works Department of Toronto.

Yours faithfully,

J. J. MASON.

HAMILTON, October 10th, 1887.

BUFFALO WATER WORKS.

The office staff consists of a head clerk, who is styled "Registrar," two book-keepers, a cashier who alone receives money, a countersigning clerk who checks the cashier, three general clerks, and eleven inspectors (one of them being chief inspector) who deliver bills and inspect and report on new services.

For rating purposes, the City is divided into four districts, each district being arranged by streets alphabetically. Each application for water is entered in the application book. The work is done by a licensed plumber, who reports when it is in readiness for the water to be turned on. One of the inspectors reports, so as to fix the rating, which is entered in the rating book. The applicant receives a bill, pays the cashier, and an order is then given to an inspector to turn on the water.

Any addition to or deduction from any existing service is treated in precisely the same way as an original application.

The rules and regulations relating to the introduction, supply and consumption of water are fully set forth in printed form for general use.

The rates as a rule are payable half-yearly, in advance, on the 1st May and 1st November; meter rates and a few others being payable monthly.

The description register or rating book is the basis from which all the bills are made out; they are then entered on the street ledgers, and are then delivered by the inspectors.

The consumer brings the bill to the cashier, with the money. It is stamped, paid, entered by him in his cash book; and also stamped and entered at the same time in a duplicate book by the countersigning clerk. Hands over the amount to the City Treasurer, taking his receipt, which receipt and a memo of his takings for the day he hands to the Registrar.

Alternate cash books are used; the one not then in use being in the hands of the checking clerks, who mark off the receipts on the street ledgers.

The street ledgers are balanced as at the 31st December in each year; the arrears which, owing to the strict rules as to stopping the supply, are very small, being brought forward to the new ledgers.

There are at the present time about 26,000 services, and on a few days in May and November as many as 2,000 bills have been paid to the cashiers in

one day. On these busy days the cashier has an assistant, who enters the amounts in the cash book, the cashier simply taking the money and receipting the bills.

DETROIT WATER WORKS.

In Detroit the system relating to new water takers and changes is practically similar to that in force in Buffalo, though the system as to rating and receiving is different.

The City is divided into five districts, with a rating clerk who is also a collecting clerk, in charge of each.

The rating is made once a year, in May and June, for the year commencing 1st July following, the assessment being added up, checked and transferred to the office book.

The rates are payable quarterly in advance, in July, October, January, and April; the rate for each family, exclusive of extras, being $5 per annum.

If not paid in the first thirty days, a penalty of five per cent. is added; if not paid in the quarter the penalty is ten per cent., and the water is then shut off.

No bills are delivered during the first thirty days of the quarter, water takers simply going to the office, paying the amount due and getting a receipt, the particulars being entered on the stub of the receipt book.

After thirty days, defaulters are notified of amounts due and the penalty; and then each collecting clerk takes a certain number of blank receipts from his receipt book, makes collections, enters in the margin of his receipt book when he returns to the office; adds up and pays over to the head receiver, showing at the same time the blank receipts not used.

The cash of each collector is kept separate during the first month of the quarter, but afterwards the head receiver keeps it.

Each collector has a "settlement book," the amounts being taken from the stubs in the receipt book, added up, checked and balanced with the head receiver, who keeps the general cash book.

One or two subsidiary books are kept relating to extra services and other matters, but practically the system is as above stated.

The number of separate assessments for 1886-7 was about 32,000, producing about $287,000.

In comparison with the number of assessments and the revenue, the office staff, consisting of 1 head receiver and 6 clerks, is very light.

The books are balanced and audited as at the 31st December in each year.

The Rating and Receiving Department being practically one Department and not two separate Departments, I do not think that the system is as perfect as it might be so far as thorough checking is concerned, and I think time is probably lost by making out what is practically a double receipt when rates are paid, but it appears to have given satisfaction in Detroit, and, as before stated, is carried out by a wonderfully small staff of clerks.

MR. HANSON'S REPORT.

WATER WORKS PUMPING HOUSE,
TORONTO, October 17th, 1887.

His Honor Judge McDougall :

SIR,—I would respectfully present the following Report of work and repairs done in and around this pumping house since I was appointed by your Honor to the position of Engineer-in-charge *pro tem*, on the 28th of May last.

The Report by Professor Galbraith and Mr. Edwin Jones will specifically refer to the state of repair of the engines and building at the time we began to make the tests and examination, as instructed by your Honor, such tests involving the condition and capabilities of the pumping house, with its machinery and appliances. Therefore, by reason of the scope of their Report, I need not refer to them further than to draw attention to the general air of dilapidation around the whole place, and the general appearance of confusion and disorder, consequent upon the mass of brick and boiler work which was so much scattered about, both inside and outside the buildings, the whole of which belonged, or had belonged to the No. 2 set of boilers then under repair. I will, therefore, confine myself chiefly to the principal repairs that have been unavoidable to keep matters moving, as well as to avert, what was at one time generally apprehended, a water famine.

That the two Worthington engines are in very urgent need of thorough repair is apparent to any one accustomed to the working of this class of machinery. In fact, remarks have been made to that effect by engineers of pumping works elsewhere, some of whom have charge of engines of precisely the same kind. The pistons of these engines need attention at once for adjustment and repair. The valves need to be examined very carefully, and the joints of the steam pipes and chests, and also of the exhaust and other pipes, from the regulator down to the air pumps, made anew. Such of them as were accessible during the time at our disposal have been renewed. Many of the pins and bearings need renewal on account of being much worn.

The difference between the pressure of steam required now for the efficient working of these engines and the pressure required formerly for doing the same work points to great defects internally, which, on account of the injurious effect upon the quantity of coal consumed, ought to be remedied as soon as possible. It is a fact well known to all users of this or any kind of engine that defects very rapidly increase, and the wastefulness increases still more rapidly. These engines, having proved so reliable for constant work, are well worthy of prompt attention in this direction.

During the time that I have had charge of the pumping house under your Honor's authority a considerable amount of repairing has been done. I will enumerate some of the chief items:

Engine No. 1 had new foot valves, and also a number of valves put in the air pump plungers. Several joints have been made in the steam and other pipes and other places. The cross-head connecting the south-east air pump to the bell crank has had a new lug and joint pin.

Engine No. 2 has had two new foot valves to replace two which by some means had been shortened 2¼ inches, which left one row of apertures open at all times, thereby the vacuum was destroyed. Several leaky joints have been made anew and others must be renewed at an early period.

With reference to the boilers—No. 2 set of boilers was under repair from early in March till the 10th of September. This, together with the extremely hot and dry weather which lasted so long and caused such a very great consumption of water that it taxed the capacity of the pumping plant to its utmost, prevented that thorough cleaning and prompt attention to the No. 1 and No. 3 sets that all boilers ought to have. Indeed, on occasions when boilers were unavoidably stopped, it caused a marked diminution in the quantity of water pumped; but, in spite of these difficulties, we succeeded in partially cleaning some of them in June and July.

During August the girders at the back ends of two of the boilers in No. 3 set gave way by reason of the long continued and great heat to which they are exposed, and had to be replaced by new ones. We took advantage of the stoppage of these boilers to give them a thorough cleaning, and at the same time some slight repairs were done to the tubes, and also to two seams in the shells thereof.

On the 10th September the No. 2 set of boilers were put into service (having first been gradually warmed, and the brickwork dried by the burning in the furnaces of a large quantity of rubbish, and also some cordwood), and the boilers of No. 3 set were stopped. Girders were put into the three boilers that had not had them changed before, so that now all have new girders. Repairs were done to the flues and shells wherever needed, and a defective flange was changed off the mud-catcher of the north boiler. All of them were thoroughly washed out and cleaned of all scale and mud. They were very carefully examined by the boilersmith and myself, and afterwards by Mr. Robb.

In addition to the above work, the furnaces and division walls were in a great part rebuilt, and made good wherever defective.

On the 27th September three of the No. 3 set of boilers were put into service and the No. 1 set stopped. These boilers were then prepared for cleaning and repairs. One of the set has had twelve tubes taken out and others put in. This one—the second from the north end—has given more trouble than any of the others, and has had to be stopped twice from the same cause - leaky tubes. One boiler had to have a new flange to the mud-catcher. The girders of three of the boilers will have to be changed, the

old ones having become bent down owing to the heat and weight of brick work upon them. They are now ready for the brick work to be proceeded with. It is worthy of consideration whether brick arches would not be more durable than the iron girders.

Regarding the Inglis & Hunter engine, the pump crank pins by loosening have caused long stoppages and delays. One loosened and fell out on the 23rd of June, causing the connecting rod to be bent and the bolts in both ends of it were sheared. A new crank pin had to be procured from Buffalo to replace this one. On examination of the others, one was found to be loose, but we were able to refit this one and use it again. Having to wait for material and work being done, we were unable to start the engine again until the 9th of July. During the time that this engine was standing idle, the two Worthington engines were unable to keep pace with the great consumption of water, and the quantity in the reservoir was very greatly reduced as the consequence.

The babbit metal in the bearings of the steam connecting rods having become worn and crushed out, and the check and check blocks of the south bearing of the north pump shaft broken, it caused a stoppage from the 22nd till the 30th of August to have them renewed.

Immediately after the closing of the Exhibition we had to stop this engine for repairs to all the pump shaft bearings. The whole of them were rebabbitted and a new check and check block put into the north bearing. At this time we found the south crank pin loose. We had to replace this pin with a new one, and in this, as in the former one, we reduced the amount of taper in the hole from $\frac{1}{2}$ an inch to $\frac{7}{32}$ of an inch. When we examined the crank pins in June this pin was quite firm. It had been refitted in November last.

This being the fourth time that a crank pin has become loosened, it is very probable that the two now in will loosen, having the original taper, at some not very remote period. I would suggest, therefore, the procuring of one, if not two, spare crank pins and have them roughed out in readiness. This would very materially shorten the time that the engine would be stopped for a crank pin which, in the present case, was over six days.

I would also suggest that the checks of the pump shaft bearings should be made of phospher bronze, this being much more capable of bearing the crushing strain consequent upon the working of the pumps than the babbit metal now in use, which has to be renewed at frequent intervals.

We have renewed a number of joints in the main steam pipes which formerly wasted much steam by leaking. There are others beginning to leak and which must be repaired at an early date.

We have gathered into one place all the cast-iron scrap ready to be carted to the press house for sale. Much old timber which had accumulated around the place, being of no value for anything else, we burned in the new furnaces of No. 2 boilers, thereby at once utilizing it for the seasoning of

the new brick work and warming the boilers, and getting rid of much that was unsightly and which gave an appearance of disorder and slovenliness to the whole place.

A quantity of glass has been put into the windows of the buildings in place of that broken. The fastenings of the doors and windows need repair, and in some cases new ones are required.

A quantity of broken stone and gravel, taken off some of the streets and brought to the works to be put into the bay, we have utilized to repair the road on the west side of the pumping house. It was in a very bad condition at all times, more especially in wet weather.

The decayed state of the engine house floor and of the covering of the well will be more within the province of Messrs. Galbraith and Jones; as also is the question of a better and cleaner method of bringing the coal into the boiler rooms, by means of light tramroads.

Respectfully submitted.

Yours obediently,

C. F. HANSON.

REPORT OF PROFESSOR GALBRAITH AND MR. EDWIN JONES.

TORONTO, October 24th, 1887.

His Honour Judge McDougall, Toronto:

SIR,—On the 28th of May last we received instructions from you to determine the duty of No. 3 engine in the Toronto Water Works pumping station · to make a general examination of the boilers, furnaces and machinery in the works; to determine the capacity of the conduit; to examine the condition of the conduit and well, and to investigate the system generally under which the works were conducted.

Mr. C. F. Hanson was appointed by you Chief Engineer-in-charge, in order to afford us full facilities in carrying out your instructions. We were not authorized to make any material changes in the present system of conducting the works, beyond what we deemed necessary for the purpose of carrying out the above instructions. We were empowered to suspend any or all of the employees should we deem such a course necessary for making a proper investigation. (We may take the opportunity of saying in this place that we did not find it necessary to use this power; on the contrary, the employees showed in many ways their willingness to promote the success of the investigation.) We were formally recognized and confirmed in the above powers by the Water Works Committee, at a meeting held in the City Hall on May 30th.

DETAILS OF THE PROPOSED TEST.

The details of the test of No. 3 engine which we proposed to make are as follows: Test to be of 24 hours' duration, coal and ashes to be weighed, water entrained in steam to be determined, leakage of steam to be reduced to a minimum and estimated, water pumped to be measured, and average head through which the water is pumped to be measured.

The weighing of the coal and ashes determines the per centage of combustible matter in the coal. The measurement of the feed water, water entrained in the steam and the leakage determines the amount of steam made. The measurements of the fuel and steam determine the efficiency or evaporative power of the boilers. The measurements of the steam used and of the work done in pumping determine the efficiency of the engine. In making a test it is necessary to read steam and water gauges on boilers, counter on engine, water pressure and vacuum gauges on discharge and suction pipes of pumps, steam and vacuum gauges on engine, float gauges in well, temperature of feed water, etc. Some of these readings are necessary for making calculations, others for ensuring the maintenance of uniform conditions during the test. In addition, indicator diagrams are to be taken at proper intervals from the steam and pump cylinders in order to ascertain the work lost in the resistance of the machinery of the engine and of the pump passages.

All instruments for measurement, such as gauges, thermometers, indicators, weigh scales, &c., are to be tested before and after the engine test. In order to determine the actual amount of water pumped, as distinguished from the nominal amount indicated by the counter, it is necessary to make a very careful measurement of the well and of all solids in it displacing water. Float gauges are also required to note the rate at which the water rises in the well during the experiment. This measurement also determines the capacity of the conduit. The leakage of Bay water into the conduit and well is to be determined by closing the outer end of the four-foot wooden pipe and observing the time required for the water to rise. In doing this great care is to be taken not to lower the water in the well more than about four feet below the level of the lake, as this difference of head, after the engines are stopped, will produce as much leakage through the walls of the conduit as will occur under ordinary circumstances when the engines are running. We regard the lowering of the level in the well, when the end of the four-foot pipe is stopped, to the level usual when the engine is running, in addition to being altogether unnecessary, as an extremely dangerous experiment. It would produce a collapsing pressure on the wooden pipe which might lead to its destruction. The capacity of the chimney stack is determined by measurement of its dimensions and those of the grate and other draught areas in the boilers and flues. These are the principal details of the work which, after due consideration, we proposed to carry out in connection with the test of No. 3 engine and the other points mentioned. Besides these observations and tests, such observations were to be made of the working of the Worthington engines as time permitted.

ENGINE PUT IN ORDER FOR TEST.

The first thing to be done was to put No. 3 engine in proper condition for the test. The engine was stopped on May 31st. The air pumps were first examined—the plungers and valves found to be of poor design and the valves in bad condition. The foot valves of the condenser were found in bad condition, and we decided to alter them in such manner that they could be depended upon for a considerable time. We consulted Mr. Inglis in connection with the foot valves, and made the changes with his approval. It was decided not to alter the design of the air pump plungers or valves, as we feared that it would occupy too much time. The pump cylinders were overhauled and the piston rings found somewhat worn on the under side, but it was not deemed necessary to make any changes in them. The pump valves were refaced. The rings of the steam pistons and the Corliss valves were refitted. The joint of one of the cylinder heads was renewed. In the first week in June, before the great increase in the consumption of water occurred, we took the opportunity to measure the principal dimensions of one of the boilers for No. 3 engine. This proved to be the only time that we could afford to let a boiler lie idle. These alterations and repairs were completed on the 18th of June, when the engine was started. Indicator diagrams were then taken, which showed that one

of the cylinders was doing three-fifths of the whole work. This was corrected. Diagrams were also taken from the pump cylinders which, while indicating prejudicial resistance due to contraction and interference in the water passages, proved clearly that the main cause of the undue vibration of the connecting rods of the pumps was the action of the teeth of the pinions and gear wheels. A mechanism was also attached to the pump cylinder to render visible the motion of the discharge and suction valves. (See Appendix I, plate 2.) We made arrangements with Mr. G. C. Robb to take simultaneous diagrams with several indicators during the test, in order to determine the amount of pump and engine resistance. We did not consider the Water Works indicator which we used sufficiently reliable for this purpose. In the meantime the water pressure gauge of this engine had been sent to Mr. James Morrison, brass founder, to be tested. We were informed by Mr. Oliver, an employee, that he believed this gauge had been tampered with. He had made a private mark on the gauge at some previous time when it had been in his hands. The pressure shown by this gauge was 18 pounds too high. The gauge was corrected and placed on the engine. The engine ran until about 9.50 p.m. on June 23rd, when the crank pin on one pump dropped out, causing the connecting rod to bend and badly wrenching the connection with the pump cross-head. This was due to the loosening of a set screw. It was found necessary to rebore hole in crank disc and to procure a new pin from Buffalo. In the meantime another crank pin was found loose. This was refitted. We also secured the engine crank pins from danger of dropping out by safety stops and set screws. The delays in getting these repairs made were such that the engine was not started again until July 9th.

PREPARATIONS FOR TEST.

Between May 31st and July 9th, in addition to the above work, we made the following preparations for the contemplated test: A very accurate measurement was made of the well, and the amount of water in each half-foot of depth from the surface of the lake downwards was computed. Three float gauges were constructed and placed in the well. The floor covering the well was taken up for this purpose. A head was constructed of boiler plate faced with wood to be placed on the outer end of the 4 foot pipe during the experiment, to determine leakage. Flag signals were procured and a code arranged for this experiment. Pet-cocks were placed on the suction pipes of engines Nos. 1 and 2. A vacuum gauge was placed on the vacuum chamber of No. 3 engine. A water pressure gauge, in addition to the one already on No. 3 engine, was placed on the discharge pipe. Vats were built for the purpose of measuring and weighing the feed water during the test. A platform was built on engine room floor and the vats placed in position. Connections from feed pump to vats were made ready. A Worthington water meter was placed in the feed pipe of No. 3 boilers to obtain an approximate idea of the amount of feed water required. A mechanism for taking full length indicator diagrams from the pumps was constructed and placed in position; also, the rigging for taking steam

indicator diagrams. Mr. G. C. Robb was employed to inspect and report upon the condition of No. 3 boilers as to leakage. The daily consumption of water by this time had become so great that it was found impossible to let the fires down even of one boiler at a time in order to clean the inside. The pressure shown by the water gauges on the Worthington engines was not consistent with indicator diagrams taken from these engines. These gauges were taken off and sent to Morrison's to be tested and put in good order. The gauge on No. 2 engine was found to indicate a pressure too great by 18 pounds, and that on No. 1 a pressure too great by 14 pounds. These gauges, after correction, were replaced on their respective engines. Arrangements were made to procure platform scales for weighing coal and ashes and feed water. Measurements were also taken of the different parts of No. 3 engine, and a thorough examination was made of the details of construction. The levels of the gauges, well, and pumps with reference to zero datum were carefully established. An examination was also made of the state of the well. An examination was made of the records in the Chief Engineer's office, and of the whole system in vogue for carrying on the work. We notified Messrs. Inglis & Hunter by letter on the 5th of July that we would be prepared to make the test in a few days, in order to afford them the opportunity of managing the engines during the test if they so desired. From our examination of No. 3 engine we decided that it would not be safe to run her during the test at a greater speed than 48 revolutions per minute, which is equivalent to a capacity of somewhere over 10,000,000 gallons per 24 hours.

The above work was completed by the time that No. 3 was again started, on July 9th. At this time the depth of water in the reservoir was only ten feet, and we felt that it would not be advisable to proceed with the test until the reservoir had been filled. Pumping was continued until July 13th without any gain in the reservoir. We, therefore, reported to you that it would be impossible to proceed with the test at that time, and were thereupon relieved from further duty until we should be able to proceed without endangering the supply to the City. Mr. Hanson was instructed to remain as Chief Engineer-in-charge. We reported these facts verbally next day to Mr. Boustead, and, after closing up matters at the engine house, made a general report upon the condition of affairs to the Water Works Committee, dated July 18th. Indicator diagrams taken from No. 3 engine on July 16, are shown on Plate I, Appendix I.

During June and July there had been such a marked increase in the daily consumption of coal that we considered it necessary to determine, as far as it was possible from the records in the engine house diary for 1887, whether this was due to carelessness in firing, or simply to the increase in the daily amount of water pumped. We found that from January 1st, 1887, up to May 28th, the average duty of the two Worthington engines had been 163 gallons of water pumped per pound of coal, while, from May 28th to July 9th, the duty of the Worthington engines was 171 gallons of water per pound of coal. There was no ground, therefore, for thinking that there had

been unusual carelessness in firing since we had been put in charge, but rather the contrary. No. 3 is, no doubt, a higher duty engine than the Worthington engines, and, whenever it is disabled, there is an immediate increase in the consumption of coal. This fact, taken in connection with the greatly increased consumption of water during the past summer, easily accounts for the large quantity of coal burned per week.

DUTY CALCULATIONS.

Since there has been no opportunity to make a test of No. 3 engine, we give here one reason among others for our belief that she never was capable of attaining to the contract duty of 70,000,000 foot pounds per 100 pounds of coal. A reference to the table of "Average pressure of water on pumps when working" for all the years from 1875 to 1886 inclusive, on page 168 of the Superintendent's Report for 1886, shows that the pressures at the engine house gradually increased from 88 pounds per square inch in the former year to nearly 105 pounds in the latter. The pressure for 1887, as recorded in the engine house diary, up to the time we tested and corrected the gauges, remains about 105 pounds. After we replaced the gauges the pressure fell to about 87 pounds. Mr. Hamilton's duty test of No. 3 engine took place November 30th, 1885. The pressure during the test was 106·52 pounds per square inch. Thus the pressures recorded from the time of this test up to the time we took charge practically agree with the pressure during the test. After the gauges are corrected, the pressures recorded fall too, and continue at about 87 or 88 pounds The inference is inevitable that the condition of the gauge on No. 3 engine was the same during the test as we found it before correcting it. The duty determined by that test was 74,799,512 foot pounds per 100 pounds of coal. The error in the gauge was 18 pounds, which would make an error of over 15 per cent. in the above duty, reducing it to about 64,000,000 foot pounds. The duties of the Worthington engines, recorded in the Superintendent's Report for 1886, are similarly affected by the errors of 18 and 14 pounds respectively discovered in the gauges of these engines. No. 1, instead of a duty of 57,687,764 foot pounds, had only a duty of about 51,000,000 foot pounds per 100 pounds of coal; and No. 2, instead of 57,435,356 foot pounds, had only a duty of about 49,000,000 foot pounds per 100 pounds of coal. The working duties of Nos. 1, 2 and 3, recorded on pages 64, 65 and 66 of the same Report, instead of being, for No. 1, 45,919,985 foot pounds, should be about 41,000,000; for No. 2, 47,383,176 foot pounds, should be about 40,000,000; for No. 3, 64,498,193 foot pounds, should be about 55,000,000 In these calculations there is an allowance of two or three feet of head for resistance in the pumps. Now, while such an allowance may be made a stipulation in a contract, yet in determining the true duty of the engine, it should not be made. The corrected duties are, therefore, still too high.

Having been informed that the contemplated test had been abandoned, we received instructions from you on October 4th to present such a report as was possible under the circumstances, stating the results of our investigation as far as it had gone, and containing such recommendations as we might

deem advisable. This, in brief, is the history of our work up to the present date.

RESULTS OF THE INVESTIGATION.

We propose in the following:

(*a*) To discuss the various points of No. 3 engine, indicating what we deem to be the principal faults of the engine and how they might have been avoided in making the design.

(*b*) To speak generally of the present condition of the Worthington engines, boilers, furnaces and plant.

(*c*) To describe the condition of the engine house and well, etc.

(*d*) To discuss the present system of carrying on the work.

We shall then proceed to give our recommendations as to what had better be done with reference to the above subject, under the present circumstances. This will finish the body of the Report. Appendices, giving necessary information on all the points, will be found attached to the Report.

(*a*) NO. 3 ENGINE.

It is but just to the manufacturers to say that the material and workmanship of this engine are of the best, and it is greatly to be regretted that they have been handicapped by faults of design.

Foundations.—The foundation, instead of being carried down to the rock, as it should have been, consists, we are informed, of a bed of concrete 18 inches in thickness. This concrete lies on a stratum of earth 7 feet thick, which rests on the rock. On the concrete rest four parallel brick walls, the space between these being partly filled by concrete. (We had no opportunity of verifying, by personal examination, the above statements.) The engine rests on four parallel "I" girders, which lie at right angles to the motion of the reciprocating parts, and are supported on the above mentioned walls, to which they are bolted.

Frame.—The frame consists of two independent halves not directly connected in any way, which are bolted down to the "I" girders above mentioned. On each of these parts of the frame are supported a steam cylinder and two pump cylinders. This arrangement appears to us one of the principal faults of the design. The effect of it is a tendency to rack the foundation and put the engines out of line. The reciprocating motion of one engine is, as the steam cranks are now arranged, a third of a revolution later than that of the other. The motion of a half frame is timed by that of the engine it carries, and thus the two half frames move forward and backward at different periods, causing the racking effect above mentioned. The only method of resisting this tendency is by diagonal trussing and struts between the "I" girders and between the two half frames.

The action of the steam reciprocating parts takes place above the frame connection between cylinder and main pillow block. This necessarily causes a tendency to bend the frame in a vertical plane This tendency is resisted by the bolts in the above mentioned frame connection, the fastenings of the cross-head slides and the holding-down bolts in the foundations. These bolts and fastenings, owing to the working of the engine, are constantly getting loose and aggravating the extent of the motion. In order, therefore, that this motion may be reduced to a minimum, there must be no tendency of the foundation to spring vertically, and all the above fastenings must be secure.

Steam Cylinders.—The steam cylinders were designed for a greater piston speed than has been found practicable, and hence for a high ratio of expansion. The ratio of expansion depends upon the work to be done by the pumps per revolution, and, necessarily, must remain nearly as in original design, although the piston speed is considerably less than that originally intended. The engine thus does not work as economically as if the original design had been successful. For the present piston speed a lower ratio of expansion would be more economical. This can only be obtained by having a smaller cylinder. Another advantage of the smaller cylinder and less expansion, which is perhaps of as much importance as economy of coal, is that there would be a more even pressure on the piston throughout the stroke, which is a matter of prime importance in pumping engines. For the present work the cylinder should be thirty inches in diameter.

Fly Wheel.—The fly wheel is far too small and light. There is an essential fault of design in its position.. In order to correct the uneven pressures on the gear teeth, due to using steam expansively, the fly wheel should be placed between the engine crank and the pinion, and as close to the crank as possible. This would necessitate two fly wheels, one for each cylinder. This change is impracticable on the present engine.

Steam Cranks.—There is an angle of 120 degrees between the two engine cranks. These should be at right angles.

Pump Cranks.—The present arrangement of the pump cranks is nearly the best possible and produces a nearly uniform discharge of water.

Spur Gear.—The gear and pinion are such that the main shaft of the engine revolves 72 times while the pump shaft revolves 17 times This ratio is as great as is practicable. Gear with V shaped teeth, with points only on the driving pinion and roots only on the driven gear, would have a much smoother action and at the same time be stronger. The south gear has several consecutive teeth partly broken and in the north gear a segment which was broken completely out is now held in its place by bolts which are continually shaking loose.

Crank Pins.—The taper of the crank pins is too great.

Pump Shaft Bearings.—The pump shaft bearings are very difficult of access for the purpose of repairs and setting up. In order to get out the cheek

block on one side of the shaft, it is necessary to lift the main engine shaft first and afterwards the pump shaft. Wedge blocks should be on both sides of the shaft. At present the wedge is only on one side. The crank disc also renders it impossible to wholly remove the cap of the bearings when necessary. The condition of these bearings is one of the most important things to be attended to in the whole engine. The smooth action of the gear depends very largely on this. These bearings are in very bad condition now and render the machine liable at any moment to a serious breakdown.

Pumps.—The pump piston rings have not sufficient bearing surface to prevent wear and consequent slip of water past the piston.

Valves and Ports.—The shape of the valves causes them to cant in their guides, causing undue wear in the latter and also interfering, to some extent, with the proper seating of the valve. The ports are far too small, being only about one-third of the area of the piston. The water passages are contracted very materially by the valves themselves. These defects cause undue resistance to the motion of the piston.

Air Pumps.—The air pumps in capacity have not sufficient margin. The valves in the plungers are of very poor design. The plunger packing is continually getting out of place. More time is lost during the regular running of the engine from this cause than from any other, and it also causes increased consumption of coal. The foot valves are very difficult of access for the purpose of making repairs. The bearing of the driving shaft of the air pump next the crank is fitted with no means of taking up lost motion.

Governor.—If the governor belt were to break, the engine would probably be destroyed. There is no safety stop to prevent the results of such an accident.

Gauges.—Before reading a steam gauge, the column of water condensed in the pipe should be blown out. The pet cock for this purpose is in a very inconvenient position.

Counter.—We found it possible to open the counter on this engine without using a key.

INGLIS & HUNTER FEED PUMP.

The bearings on both engine and pump shafts on the new feed pump are fitted with no means of taking up lost motion. The only way of doing this is by rebabbitting.

(*b*) THE WORTHINGTON ENGINES, BOILERS, FURNACES, PLANT IN GENERAL.

The vacuum of these engines in their present condition is very unreliable. Very severe concussions occur in the pumps owing to this cause. This also renders necessary a much higher boiler pressure than when the engines were in good condition. It is dangerous to expose the steam jackets to present high pressures. The bursting of a steam jacket would be a serious accident. The leakage of air into the condenser necessitates the continual

use of the force injection. We understand that for the past twelve months the force injection of No. 2 engine has been used almost continuously; also, that No. 1 engine has depended for about the same time partly upon the force injection for the supply of water to the condenser. The principal cause for the inefficiency of the atmospheric or suction injection is that it takes water from the well and consequently has to lift it a height on an average of about 15 feet. When the vacuum on the condenser fails, it is impossible for a sufficient supply of water to rise through this height, and then the force injection must be called into requisition. The quantity of feed water required for the boilers per 24 hours per million gallons of water pumped is about 4,700 gallons. This quantity was determined by a water metre placed on the feed pipe of No. 3 boilers when they were furnishing the steam for No 2 engine. The stop valve between boilers Nos. 1 and 2 was kept closed, so that all the steam made by No. 3 boilers went to No. 2 engine. The result of measuring the feed water and the water pumped for one week, viz., from June 4th to June 11th, was that 5,306 gallons of feed water were required to pump 1,000,000 gallons. Deducting 606 gallons as a fair allowance for drainage of steam jacket, leaks, &c., we obtain 4,700 gallons of feed water as the amount reaching the condenser per 1,000,000 gallons of water pumped Assuming No. 1 to require the same amount, we have 37,600 gallons and 18,800 gallons respectively as the quantities of feed water required by both engines when pumping 12,000,000 gallons per day. The quantity of injection water required is on an average 20 times the quantity of feed water. The engines will, therefore, use 752,000 gallons and 376,000 gallons injection water respectively per day, or a total of 1,128,000 gallons. It is impossible to estimate what proportion of this immense quantity of injection water is taken from the City mains in the present bad condition of the Worthington engines, but there is no doubt that it is very great. The importance of putting the suction or atmospheric injection in order is very apparent. A very probable cause of the bad vacuum is the suction of air through the steam chest joint on the low pressure cylinder towards the end of the stroke, at which time the pressure is considerably below that of the atmosphere. On the next stroke this air is sucked into the condenser. Another cause of the bad vacuum may be leakage of steam from one side of the piston to the other. The lagging, or covering of the cylinders and steam chest, is in very bad condition. The bolts connecting the sections of the upright suction pipes in the well are very much corroded. The foot valve on suction pipe of No. 1 is in bad condition.

BOILERS, FURNACES AND PLANT.

While we were engaged on the work of preparing for the test we had not an opportunity to examine the condition of the boilers and furnaces, as, owing to No. 2 boilers being at that time under repair, it was impossible to let down the fires. We found the stop valve in the main steam pipe of No. 3 engine so leaky as to cause the steam gauge on the engine to show considerable pressure even when it was shut. The stop valves on the steam pipe of Nos. 1 and 2 boilers are apparently in fair condition. The pit

between the bridge walls in No. 2 boilers is deep, while in Nos. 1 and 3 boilers it is shallow. It may be useful to observe in future what difference this makes in the evaporative capacities of the boilers.

Chimney Stack.—The drawings show the chimney stack to be 122 feet high and 5 feet square at the smallest crossed section of flue which is at the top. Not having measured the draught and grate areas of all the boilers in the present house, we cannot speak exactly as to the capacity of the stack. The probabilities are that it would prove too small if all the present boilers were in operation at one time, and certainly it would not be advisable to think of connecting any more boilers with it when making extensions of the pumping plant.

(*c*) ENGINE HOUSE AND WELL.

Well.—In the well is a cast-iron tank built up of plates, with planed butt joints bolted together. There are 66 plates in the sides and ends, besides those in the bottom. At least 11 of the plates are cracked. Three of these cracks leak considerably. The leakage through the other eight is unimportant, being prevented by the filling of cement and gravel between the tank and masonry of well. The cracking of the plates was caused by the bursting pressure of this concrete. The struts between the opposite side plates of tank have in many cases been badly bent by the immense pressure to which they have been subjected. There are two leaks in the masonry of the well above the tank. A joint in the discharge pipe from No. 2 air pump also leaks into the well. There are signs of leakage through the masonry from the pits of the Worthington engines. There is also a leak from engine pits between pipes from No. 1 air pump and masonry. There is a deposit of mud at the bottom of the well which is at least eighteen inches deep at the north end. The well is in by no means as clean a condition as is desirable. The flooring and joists covering the well were found in a very decayed condition. (The cracks and leaks in the well are shown in Appendix I., plates, 3, 4 and 5.)

Engine House Floor.—The wooden floor of the room containing the Worthington engines seems to be in a bad condition. It is probable that the joists supporting it, and the under half of the double flooring, are decayed. This is due to their being kept in a damp state by the vapor arising from the engine pits and water in the foundation. The stone floor in No 3 engine room is very uneven and unsightly, many of the stone flags being broken.

Boiler Rooms.—The present method of carting coal into the boiler room for Nos. 1 and 2 engines necessitates carts being driven around to the front of the building, cutting up the drive and rendering the appearance of the place unsightly. The carting of coal also makes it necessary to keep the doors open in the winter time much longer than they ought to be. The walls and windows are very dirty, and the floor is very uneven, having been broken by the carts. It is very difficult to shovel coal on such a floor or keep it decently clean.

Ashes.—There is apparently no proper place for dumping ashes.

Re-Painting.—The woodwork of the whole building needs re-painting.

(*d*) THE PRESENT SYSTEM.

Under the present system, or rather want of system, there are no means of keeping check on the employees. If the work does not go on properly, it is almost impossible to locate the fault. It is utterly impossible to control the consumption of coal, oil, waste, etc. Men, under such a system, are liable to become careless and indifferent. We might, in fact, sum up the whole matter in saying that the system is one that no one would tolerate for a day in his own business.

RECOMMENDATIONS.

(*Note.*—Under this head there will necessarily be an appearance of repetition of many of the points already discussed.)

NO. 3. ENGINE.

Owing to the shaky, and, to us more or less unknown condition of the foundations, we cannot think of recommending changes with regard to all the points upon which we touched in discussing No. 3 engine. As it will be necessary very soon to build a new pumping station, we think that only the more urgent and less expensive alterations should be carried out. We think that we have already given sufficient information to guide the City should they choose to proceed any further in the matter of alterations than we at present propose.

Steam Cranks.—The two steam cranks should be placed at right angles to each other. In doing this care must be taken not to disturb the present relative positions of the pump cranks, as the latter are very well arranged. The shorter part of the engine shaft is to be uncoupled, lifted out of gear, turned one hole in the coupling and lowered again, the gear below the pinion being moved no more than is necessary to allow the teeth to mesh. If this motion of the gear is found necessary it would be better to turn it so that the angle between the cranks of the second and third pumps is made smaller by one tooth rather than in the opposite direction. This change will materially help the action of the fly wheel.

Spur Gear and Pinions.—The V gear, already described, would be much more expensive than the present kind, and, owing to the shakiness of the engine and foundations, would not prove as successful as if the engine were solid. We, therefore, do not take the responsibility of advising it. The present gear are liable to fail at any moment, and new gear should be procured. We would prefer a ratio of 4 to 1 instead of 72 to 17. This would necessitate a new pinion also and new patterns. This would reduce the shaking of the engine, since the steam and pump cranks would come into the same relative positions once every four revolutions of the former, instead of once in 72 revolutions as they now do. This would help the fly wheel considerably in regulating the pressure on the pumps.

Pump Shaft Bearings.—The pump shafts must be immediately lifted and the bearings put in proper condition. The babbit metal hitherto used is too soft. Bronze side cheeks should be put in and the cap and bottom babbitted with a composition of copper, tin and antimony, in proper proportions. Instead of only one wedge-block, as at present, there should be one on each side of the bearing, if due examination of the bearing, after the shaft is lifted, shows this to be practicable.

Engine to be run in opposite direction.—When new gears are put in, the engine should be made to run in the opposite direction to the present, *i.e.*, to run *under* instead of *over*. The effect of this would be to destroy the tendency which exists at present of the pump shaft to rise in its bearings, which causes a jolting action on the cheeks, striking them very heavy blows when the crank is passing the centre. If the engine runs *under*, the pump shaft will be kept down on its seat, and the side action above mentioned will be changed to a steady pressure instead of a blow. With the new bearing above suggested there will arise no injury on account of the increased pressure on the bottom of the bearing.

The effect of the engine running *under* is to relieve the upper side of the cross-head guides from pressure during part of the stroke, and to transfer it to the under side. If the gibs are properly adjusted this will be a benefit rather than otherwise, since it will materially reduce the friction on the slides. This remark applies also to the pump cross-head and slides.

Pump Piston Rings.—Another ring should be placed on the pump piston between the present rings, or else the latter should be replaced by others having larger bearing surface. (See Appendix I., plate 6.) There is, no doubt, considerable leakage past the piston, and consequent waste of coal on account of the wear in the present rings.

Pump Valves.—Valves of a new pattern should be procured. (See Appendix I., plate 7.)

Air Chambers.—An air chamber should be put on the discharge pipe of each pump, and charged by means of a petcock on the suction pipe. This would relieve the engine to a considerable extent from the jar caused by the blows of the teeth of pinion and gear. (See Appendix I., plate 8.)

Air Pumps.—New plungers should be procured, with different valves from the present. The ordinary plunger, with circular gratings for the valve seat and ports, and a single annular rubber valve, with a curved guard, would be substantial, and serve the purpose well. Instead of ordinary packing, we would advise corrugations, *i.e.*, small recesses turned on the plunger for water packing.

Governor.—The governor should be furnished with a safety stop. (See Appendix I., plates 9 and 10.)

Counter.—The counter on the engines should be sealed. This applies also to the Worthington engines.

REQUISITES OF A GOOD PUMPING ENGINE.

It may not be out of place for us to call attention here to what we consider the requisites of a good high duty pumping engine. It should be a compound condensing engine, steam jacketed, with fly wheel. These are the characteristics of the steam side of the majority of high duty engines that we are acquainted with. The mechanism should be as simple as possible, and the number of working parts reduced to a minimum. All wearing surfaces should be large. All parts of the machine should be easily accessible for examination and repairs. There should be no doubt about the solidity of the frame and foundation. The pumps should be furnished with valve openings equal to or greater in area than the area of the piston. The valves should be many in number and of low lift, in order to reduce slip to a minimum. The motion of the piston should be comparatively slow. The engine should be placed so that its suction or atmospheric injection may have a low lift and a short pipe, in order always to give an ample supply of injection water to the condenser. The air pumps should be ample.

THE WORTHINGTON ENGINES.

All the points discussed above in reference to the Worthington engines should receive immediate attention. The great difficulty in the way of doing so is that if one of the Worthington engines is taken apart the City is left at the mercy of an unreliable engine. It might perhaps be better to defer the repairs of the Worthington engines until the suggested alterations in No. 3 have been completed. No time should be lost, therefore, in carrying these out. In order to make the suction injection reliable, and so do away with the present waste caused by the continuous use of the force injection, the former should take water from the lake level and not from the well.

In the Annual Reports of the Superintendent, a nominal allowance for three per cent. for slip of pumps is made in the monthly duty calculations. As the actual slip is utterly unknown, we recommend that in future Annual Reports no such allowance be made. It is simply guess-work.

BOILERS AND FURNACES, ETC.

Now that there is a spare set of boilers, a regular system of cleaning should be adopted. The intervals between washing out depend both on the nature of the feed water and the peculiarities of the boiler. The Engineer-in-charge should decide as to the proper intervals at which washing out should take place, and see that it is done regularly. The tubes should be cleaned at least twice a week, and in such order as not to let down the steam pressure.

WELL.

We do not see that there is any urgent necessity for making any immediate alterations in the well. The breaks in the tank must have taken place very shortly after the tank was put in, and the money spent on this work has been literally thrown into the well. As to the effect of the leaks on

the nature of the water, we believe that the City Council have the reports of Dr. Ellis and Professor Wright, who made their examination this summer. These reports should govern, to a great extent, the action to be taken in this matter. When a new engine house and well shall have been built, it will be an easy matter to fill up the reservoir and then begin putting in a new tank, which should be high enough to reach above the highest lake level. The top of the present tank is two feet below zero datum, and this summer the lake level was at least five feet above the top of the tank. The new engine working constantly, together with a full reservoir at the start, would afford sufficient time to make a good job in putting in a new tank, provided full preparations had been made. In this connection it may be advisable to suggest that the new well be connected with the present one. This would give a higher well level to pump from. No cement backing should be used between the tank and the masonry. The tank, if properly tied, is sufficiently strong and should be made water tight in itself, and not depend on any cement, or anything outside of it, to render it reliable in that respect. The present accumulation of mud in the well should be removed. The well seems to act as a miniature settling basin; but it may be that there is so much mud in it now that an undue quantity may be carried up the suction pipes, especially that of No. 1 engine, where the accumulation is the greatest.

GATE ON CONDUIT.

There should be a proper gate, or stop-valve, placed in position at the end of the wharf, on the conduit leading into the well.

FLOOR OF ENGINE ROOMS.

The floor in both engine rooms should be removed and replaced by a floor of two inch oak plank, tongued and grooved, with seams laid with white lead. This should rest on rolled iron girders. Trap doors should be made wherever necessary, and there should be no confined air spaces under the floor. All empty spaces under the floor should be properly ventilated.

FLOOR OF BOILER ROOMS.

The floor in the boiler rooms should consist of stone flags solidly and evenly laid.

TRAMWAY.

A tramway should be laid from the coal house through the passage back of No. 3 boilers, into Nos. 1 and 2 boiler room. The rails should be of pattern shown on Appendix I., Plate 11, so as to interfere as little as possible with the shovelling of coal, and at the same time be easily kept free from coal. A similar tramway should switch off to No. 3 boiler room.

DUMP CARS.

About a dozen side-dumping cars, holding a ton each, should be procured for the purpose of delivering the coal, instead of the present carting system. This would enable the front doors of Nos. 1 and 2 boiler room to be kept closed during the winter. This would render it possible

to keep the front of the pumping station in good order. The door of No. 3 boiler room could also be kept closed for a much longer time than under the present system.

WEIGH SCALES.

The tramway system would render it necessary to remove the weigh scales to the door of the coal house.

SIPHONING.

Using the steam siphon for the purpose of emptying out the pits under the floor is very wasteful of coal. A special pony pump not easily injured by grit or dirt should be procured for this purpose. It should be placed in some central position, and supplied with a sufficient amount of hose.

MACHINE AND CARPENTER SHOP.

There should be a proper room or closet for tools There should also be a repair shop, furnished with a portable forge, vises and hand tools, for the purpose of making small repairs. The carpenter shop should be connected with this under the same roof.

PROPOSED SYSTEM.

We now come to what we consider the most important matter connected with this Report, namely, the substitution of an entirely new system of carrying on the work. In devising the proposed system, we endeavored to combine efficiency, cheapness and practicability under existing circumstances, with what success remains to be seen. The general principle adopted was to endeavor to make the work check itself, and to place upon every employee his proper share of responsibility, so that when faults occurred they could be traced without difficulty to their source, and no blame be cast upon innocent persons. There will no doubt be some trouble at first in getting men, accustomed for so long a time to no system, to work into that proposed, but that difficulty will not last long. To carry out the new system the chief engineer must have a clerk, as there will be a great addition to the clerical work to be done by him This is the only addition to the present staff which we propose. The work of the pumping station will be divided into three watches, as at present, viz., from 8 a.m. to 4 p.m., 4 p.m. to 11 p.m., and from 11 p.m. to 8 a.m. The same number of men will be employed on each watch as at present. We shall explain our proposed changes under three heads, viz.,

FIREMAN.

Each boiler room is to be furnished with barrows, the boxes of which are to have four sides instead of three. The boxes of all the barrows must be of exactly the same size. When firing, the fireman is to fill the barrow full, striking off the top with a straight edge, and then dump the load before the boiler. The boilers are to be numbered. The fireman then makes a tally on a form provided for his watch opposite the number of the boiler at

which the load is dumped. (See Appendix II., form B.) The average weight of a barrow load is to be tested by experiment from time to time, whenever the Chief Engineer considers it necessary. The best way of doing so would probably be to put on observers to count the total number of barrow loads used in one of the boiler rooms per 24 hours. The weigh master will keep a separate account of the coal put into each boiler room per 24 hours, and give a statement of the amounts daily to the Chief Engineer on Form A., Appendix II.

Bonus for Correct Measurement.—In order to give the firemen some inducement to measure their coal, and not throw a portion on the fires without first passing it through the barrows, we propose that a bonus of twenty-five cents be given to each of the firemen employed during the three watches (*i.e.* 24 hours) in one boiler room when the united sum of their tallies agrees within a certain percentage, to be determined by the above mentioned experiment with the weight of the coal charged against that boiler room for that day by the weigh master; and that a fine of twenty-five cents be imposed on all the firemen in that boiler room during the three watches if the total amounts for the twenty-four hours do not agree within a certain wider percentage. This will create a spirit of emulation in exact measuring, and if any man wilfully cheats, or fails through grudges against the others, or laziness, it will be to the interest of the others to discover him. Any failure in measuring can thus be left to be dealt with by the men themselves. The difference between the total measurement and the total weight per weigh master's certificate is to be divided by the Chief Engineer among the watches proportionately to the respective quantities measured.

Economy in Firing.—The proper method of comparing the men on one watch with those on another, in respect of economy in firing, is not by determining the amount of work done per ton of coal. This depends upon the engine and the engineer as well as the firemen, and it is quite possible that the firemen on one watch may be using coal more economically than those on another, although less work may be done per ton of coal by the engines.

Evaporation per pound of Coal to be Determined.—The only true way of comparing the men on different watches in respect of economy is by comparing the amount of steam made by them per pound of coal. What is done with the steam afterwards is of no importance to the firemen. It is the Assistant Engineer's business to make proper use of the steam. It will thus be necessary for the firemen of each watch to record the amount of steam made during their watch. For this purpose a meter must be put on the feed pipe of each set of boilers and readings taken by the firemen on the watch at both beginning and end of the watch. These readings will be entered on the fireman's form. The steam pressures on the boilers will also be entered by the firemen on the form. At the end of the watch the form, signed and dated, is slipped into the letter box in the Chief Engineer's office. The watch from 11 p.m. to 8 a.m. must receive instructions to leave a clear space for the new coal to be delivered in the morning, in order that

it may not be mixed with the unused coal from the night before; and the next watch must use up all the coal left from the previous watch, and enter it separately in their record before beginning on the new. This is necessary in order to enable the daily check to be made on the measurement. It will be impossible to check the coal delivered on Saturday for Saturday and Sunday separately. The check must be applied to the total amount for the two days.

Bonuses for Economy in Firing.—A system of bonuses should also be adopted, based upon the economy of the watches in their use of the coal. Instead of adopting some standard and bonusing the men if they do better than the standard, it would be much preferable to bonus the men each week, provided they made a certain per centage of improvement upon the previous week. Three per cent. would probably be a good per centage to start with; and as the men improved this would have to be reduced in order to still keep up the inducement, so that in course of time the same reward would be given for an improvement of one per cent. or less on the previous week's record, as was given at the start for one of three per cent. The Chief Engineer will have a proper form for entering these records. (See Appendix II., Form F.) Of course all the firemen on the same watch in the same boiler room get equal credit. No distinction can be made between the men on the same watch. A separate weekly record will be kept for each man, however, and on this record he will be judged. The same men are not always together on the same watches. We feel that this is the only proper method to get good work out of the men. It will give them an interest in their work, and the faults of the engine will not be saddled on the fireman. It is not intended, however, to relieve the Assistant Engineer on watch of his responsibility in the boiler room. He must still see that the firemen do their duties properly, and be responsible to the Chief Engineer for all the work carried on in his watch. This system will relieve him, however, it is believed, of a great deal of trouble in the boiler room.

Weighing Ashes.—From time to time an experiment of 24 hours duration in weighing the ashes, and thus determining the per centage of combustible in the coal, should be carried out. A stipulation should be made in the coal contract, that deductions be made from the contract price whenever the proportion of ash rises beyond a certain amount.

Alternative Methods of Determining the Quantity of Coal.—Instead of measuring the coal in barrows it might be weighed on scales on the boiler room floor. However, this would involve the employment of an additional hand in each boiler room for each watch to weigh the coal, as the wheeling of all coal to the scales would make far too much work for the present number of men.

Having the coal weighed into trucks by the weigh master for each watch by the weigh master is another method; but, unless the weighing were done on Sundays as well as on week days, this system would work only for five days in the week, as Saturday's and Sunday's coal would be mixed unless

an enormous number of trucks were employed, with the necessary switches and sidings.

ASSISTANT ENGINEER.

The Assistant Engineer will record upon Form D three times during the watch, viz., at the beginning, middle and end, the following observations:

Feed water meter.

Counter reading.

Steam gauge.

Vacuum gauge.

Water pressure gauge.

Depth of water in well.

As he has charge of two engines and two sets of boilers at a time, this will necessitate eleven observations each round. He will also enter his name and that of his oiler, with date of watch. At the end of his watch the form thus filled up is to be slipped into the Chief Engineer's letter box. The Assistant Engineer will be responsible to the Chief Engineer for the management of the whole work in the engine house during his watch.

Separate Lockers for Oil and Waste.—Each Assistant Engineer will have a separate locker, which will be kept supplied with all the necessary oils and waste, to which he alone will have access. An account will be kept with him of the quantities supplied. At the end of each month the quantities on hand will be measured and the quantities used by him entered on a form to be kept for that purpose by the Chief Engineer. (See Appendix II., Form H.) From these returns the Chief Engineer will make up a monthly statement, showing the work done by each assistant engineer, with each engine per pound of steam supplied—(not per pound of coal) · also, of the oils, waste, etc., used by him on each engine. (See Form G and H, Appendix II.) To the Assistant Engineer who shows the best annual average, we would propose to give a bonus of $100 per annum, and one of $50 to the second best.

Note.—Sometimes when the two Worthington engines are working the steam from the two sets of boilers is mixed, so that it will be possible only to compute only the combined efficiency of the two engines when such is the case. However, this will cause no trouble in the use of the proposed forms, and will not interfere with the separate computation of the evaporative capacities of the two sets of boilers.

THE CHIEF ENGINEER.

The Chief Engineer, assisted by his clerk, will each morning collect the ten forms which he will find in his letter box (3 from each boiler room, 3 from the engine rooms and 1 from the weigh master.)

File Book containing Forms A, B and D,—and paste them in a large book filled with brown paper leaves, called the File Book. He, or his clerk, will

then make the necessary calculations to fill up the remaining blanks in these forms, and enter the results in their proper places. This book will thus furnish the material from which he can determine the character of the work of firemen and boilers, assistant engineers and engines.

Fireman's Weekly Record.—(Form F).—Thus from this book he enters up weekly the information in the Fireman's Book, which is filled with pages ruled according to Form F, stating the weekly work of each fireman and showing the bonuses and fines to which he is entitled.

Assistant Engineer's Monthly Record.—(Forms G and H).—In the Assistant Engineer's Book, paged according to Forms G and H, he enters up daily the foot pounds of work per pound of steam, obtained by the Assistant Engineer out of each engine. The monthly oil record is kept on Form H in this book. The proportionate quantities of oil used in a given time by each engine may be roughly ascertained by observation, and the quantity of oil used each month by each engine may be pretty closely estimated by dividing up the total quantity roughly in these proportions. From the monthly averages in this book the yearly averages can be easily obtained, which will show what engineers are entitled to the $100 and $50 bonuses. The information in the file book, which is not transferred to the Assistant Engineer's book every day and which is not required for the calculations, viz., the steam and vacuum gauge readings are noted by the Chief Engineer from day to day simply that he may become acquainted with any temporary derangements that may take place, and immediately take the necessary steps to remedy them.

Chief Engineer's Monthly Record.—Form I.—The Chief Engineer will also make up from the Fyle Book, and enter in a book paged according to Form I, the daily record of the total water pumped and total coal burned, lake, well and reservoir levels, the daily duties of the engines per pound of steam averaged each day from the three watches, also the daily efficiency in pounds of steam per pound of coal of each set of boilers averaged from the three watches. He will thus be able to follow from day to day the condition of the engines and boilers.

Chief Engineer's Monthly Oil Record.—Form J.—The Chief Engineer will make up from the Assistant Engineer's record the quantities of lubricants used by each engine per month, and their cost. On this form he will also enter cost of miscellaneous material used monthly.

Accident and Repair Book.—Form E.—The Chief Engineer will keep an accident and repair book, paged according to Form E. His clerk will keep the time, in hours, of employees engaged on repairs, and, when the repairs are finished, the total times of each class of labor, such as machinist, carpenter, labourer, etc., will be entered on this form, charged at usual rates. Material bought and outside work done will also be charged according to the accounts sent in. The Chief Engineer must, therefore, receive copies of all such accounts, or the original must pass through his hands for this purpose.

The repair book should be divided into seven parts, viz., one part each for the three engines and the three sets of boilers, and the seventh part for all other repairs. The total repairs in each part are to be summed up monthly.

Chief Engineer's Boiler Room Record.—Form C.—The Chief Engineer will keep a record of the times of cleaning boilers. This record will also show what boilers are not in use day by day, although in good order, and what boilers are disabled.

Chief Engineer's Annual Report.—Form K.—From the above forms the information is collected which is given in the Chief Engineer's Annual Report, Form K. The Chief Engineer will also keep a diary containing any necessary information not provided for in the above forms. He should be provided with a letter book and a copying press.

CONCLUSION.

From our observations of the present method of carrying on the work we feel assured that the system above proposed is perfectly practicable. As before mentioned, the only addition to the staff, which will be required, is a clerk to the Chief Engineer. This clerk could act as time-keeper for time of men engaged in repairs. He could also keep a list of all tools and see that they were returned to their proper places, measure out oil to the engineers, and render himself generally useful. What we propose is simply a system of book-keeping adapted to the requirements of the pumping station and based on correct principles. If adopted, it will render it almost an impossibility for anything to go wrong without receiving almost an immediate check. The Chief Engineer, on referring to his books, will be enabled to see at a glance the daily condition of everything for which he is responsible. He will be able to trace, day by day, improvement or depreciation in the plant, and will be able to furnish exact information on a moment's notice to his superior officer. As things are conducted at present it is almost impossible to get reliable information on any subject connected with the works. If there is to be any improvement on the present condition of affairs, some system embodying the principles which we have endeavored to formulate must be adopted.

Respectfully submitted.

(Signed) J. GALBRAITH.
EDWIN JONES.

APPENDIX I.

Plate 1—Indicator diagrams from No. 3 engine taken July 16th, 1887.

Plate 2—Valve diagrams from pumps of No 3 engine. Indicator diagrams from pumps of No. 3 engine and from pumps of Worthington engine.

Plate 3, 4, 5—Well and tank, showing cracks and leaks.

Plate 6—Present and proposed piston rings in pump of No. 3 engine.

Plate 7—Proposed pump valves for No. 3 engine.

Plate 8—Proposed air chamber to be placed on discharge pipe of each pump of No. 3 engine.

Plate 9 and 10—Proposed safety stop for governor of No. 3 engine.

Plate 11—Cross section of portion of tramway in boiler rooms.

NOTE.—As none of the above drawings are intended for working drawings, no dimensions or scales are given.

PLATE 1

INDICATOR DIAGRAMS
from
ENGINE No. 5.
July 16 1887

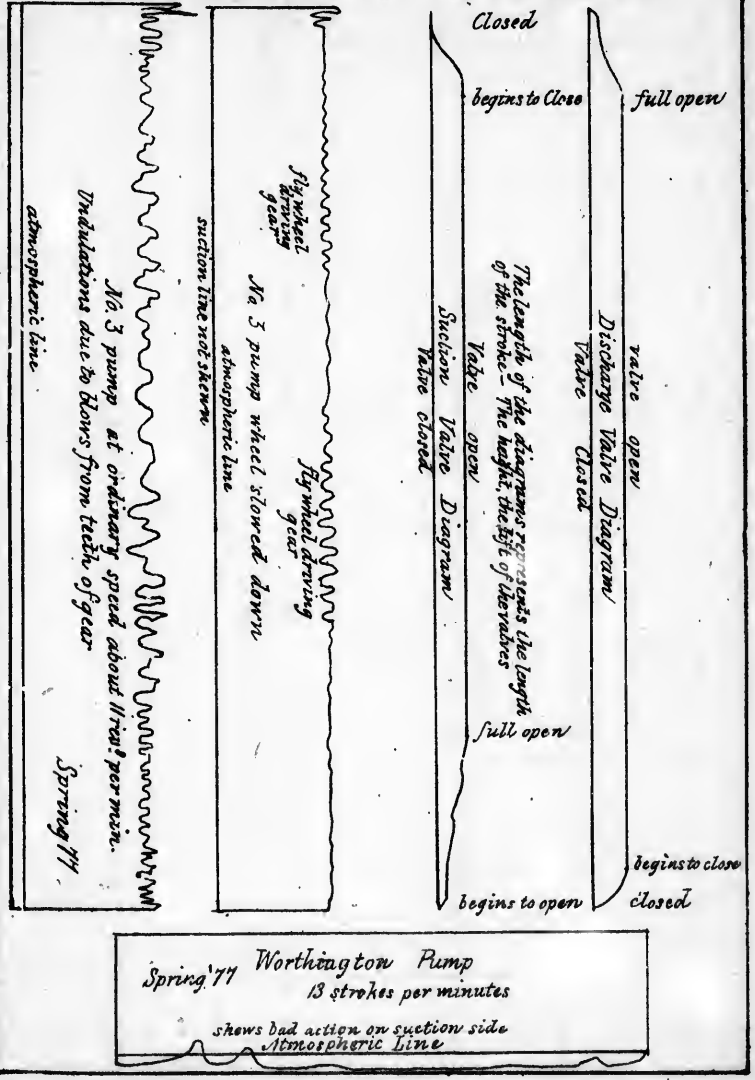
Cylinders 32" diam. x 48" Stroke.
Spring 77

South Engine
Horse Power 276.

Revs. 49¼

North Engine
Horse Power 278

PLATE 2. DIAGRAMS Shewing ACTION of VALVES of No 3 PUMPS and INDICATOR DIAGRAMS FROM PUMPS of No. 3 & No. 1



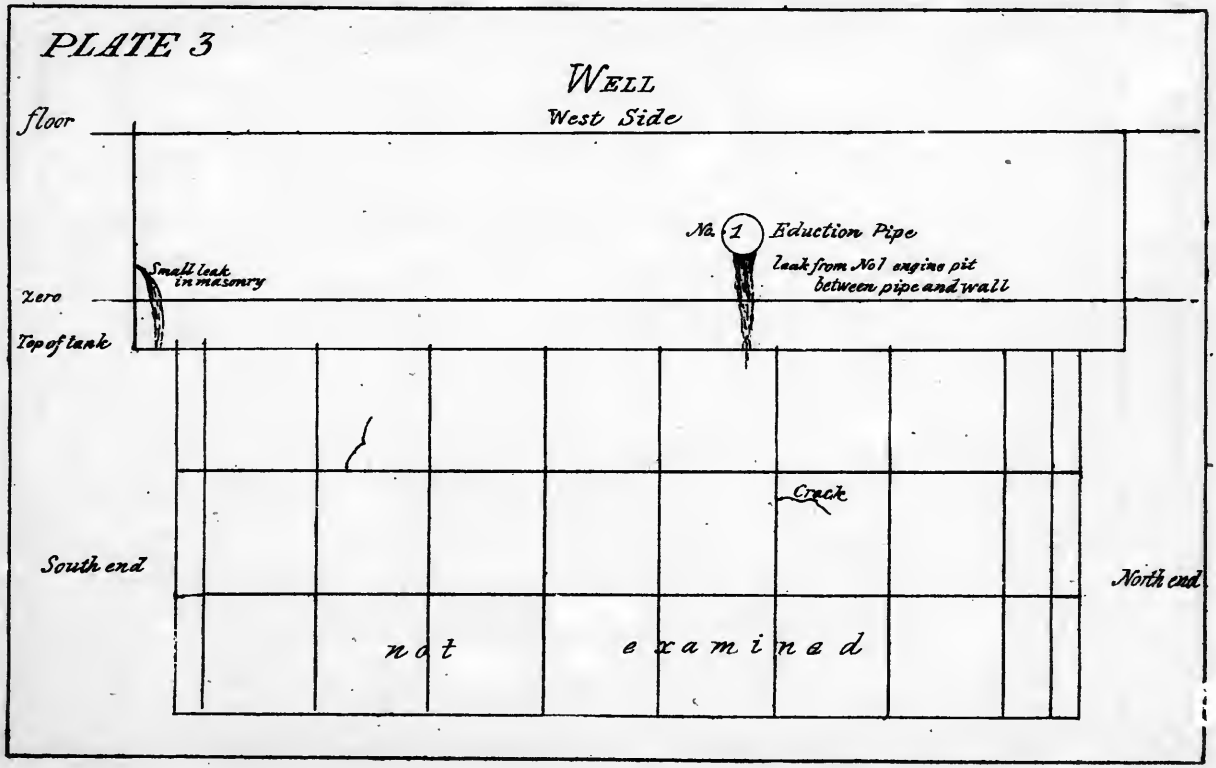


PLATE 3
WELL
West Side
floor
No. 1 Eduction Pipe
Small leak in masonry
leak from No 1 engine pit between pipe and wall
Zero
Top of tank
Crack
South end
North end
not examined

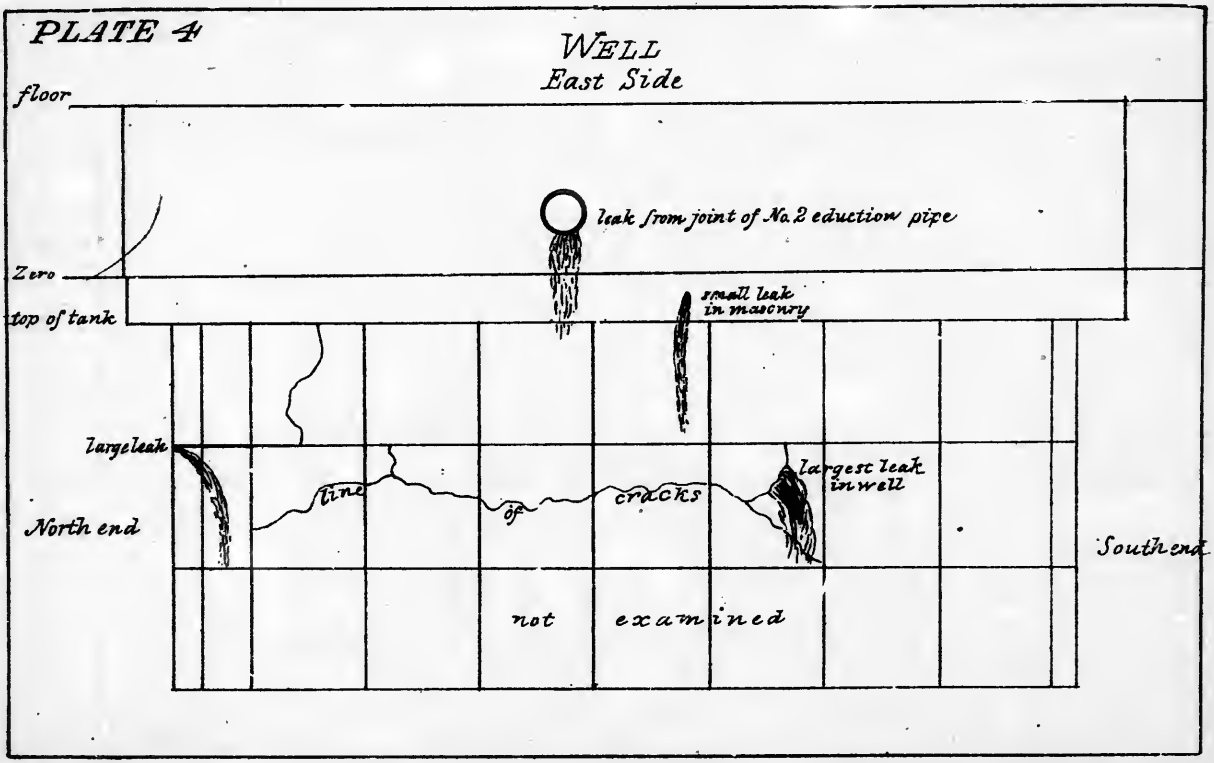


PLATE 4
WELL
East Side
floor
leak from joint of No. 2 eduction pipe
Zero
top of tank
small leak in masonry
large leak
line
of
cracks
largest leak in well
North end
South end
not
examined

PLATE 5.

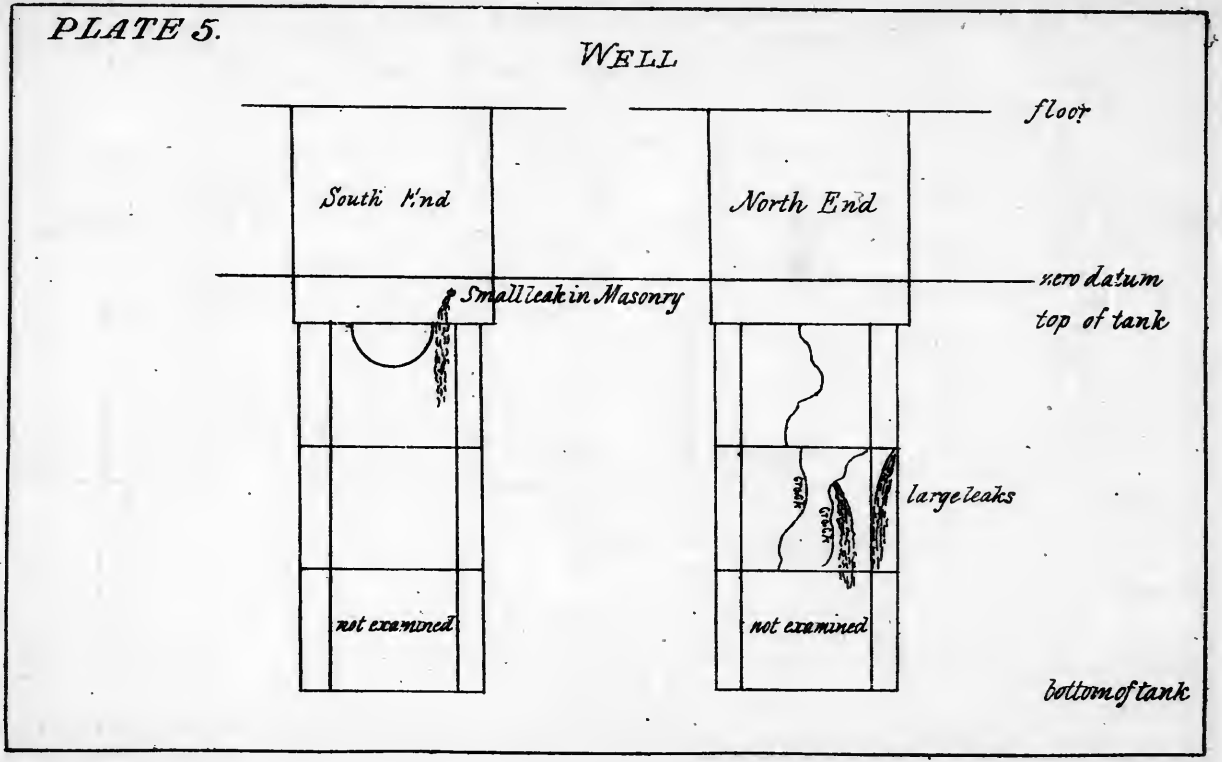
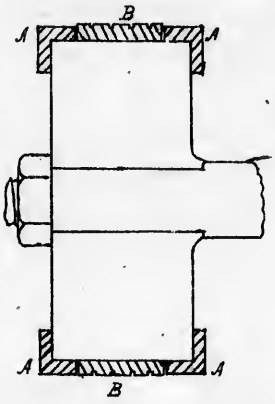

WELL
floor
South End
North End
zero datum
top of tank
Small leak in Masonry
large leaks
not examined
not examined
bottom of tank

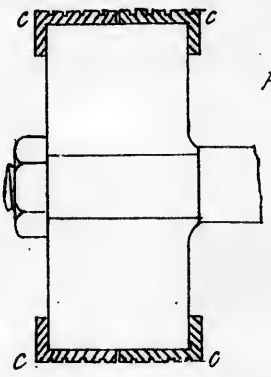
PLATE 6.

PISTON RINGS for PUMP



A.A.A.A. Present Rings
B.B. Additional Ring proposed

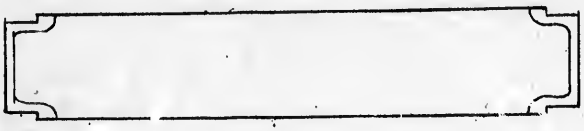
or



Remove Rings A.A.A.A.
and
Replace by Rings C.C.C.

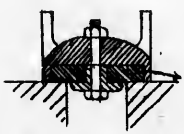
PLATE 7.

PUMP VALVE



Plan

Longitudinal Section



Cross Section

End View

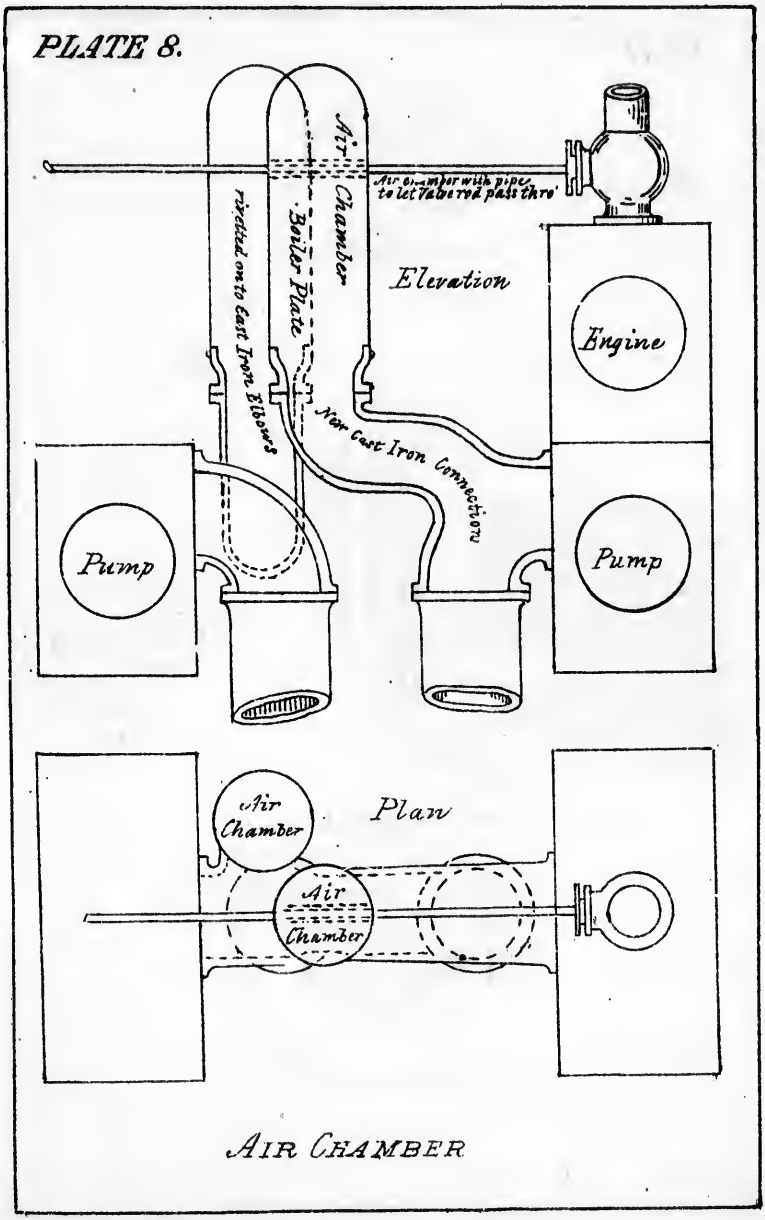
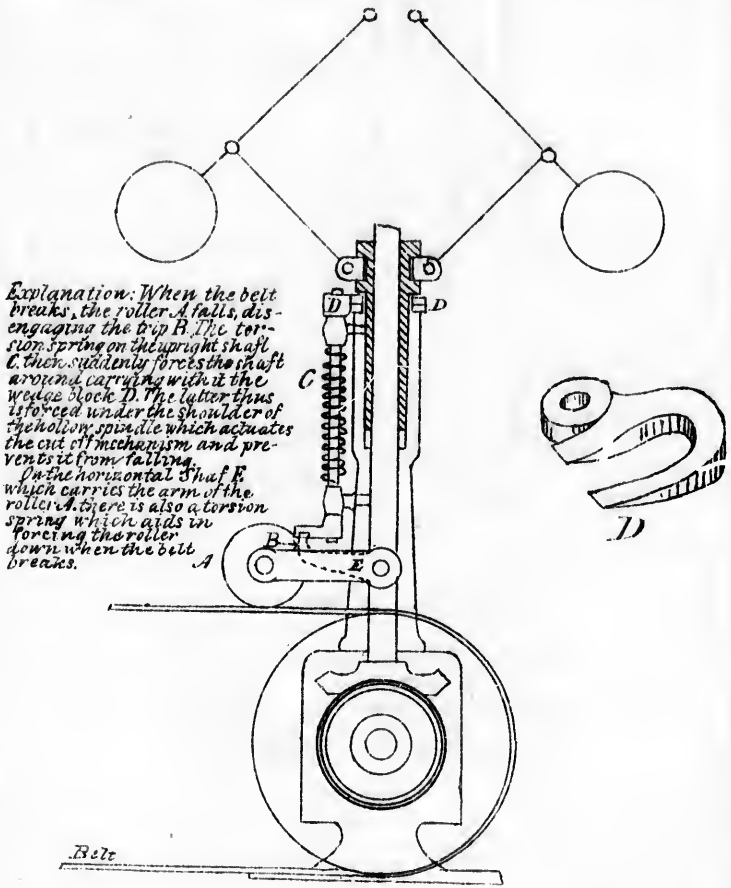


PLATE 8.
Air Chamber
Boiler Plate
riveted on to Cast Iron Elbows
Air Chamber with pipes to let Valve rod pass thro'
Elevation
Engine
New Cast Iron Connection
Pump
Pump
Air Chamber
Plan
Air Chamber
AIR CHAMBER

PLATE 9.

SAFETY STOP for GOVERNOR

Elevation



Explanation: When the belt breaks, the roller A falls, disengaging the trip B. The torsion spring on the upright shaft C, then suddenly forces the shaft around carrying with it the wedge block D. The latter thus is forced under the shoulder of the hollow spindle which actuates the cut off mechanism and prevents it from falling.

On the horizontal shaft E which carries the arm of the roller A, there is also a torsion spring which aids in forcing the roller down when the belt breaks.

PLATE 10

SAFETY STOP
for
GOVERNOR

Plan

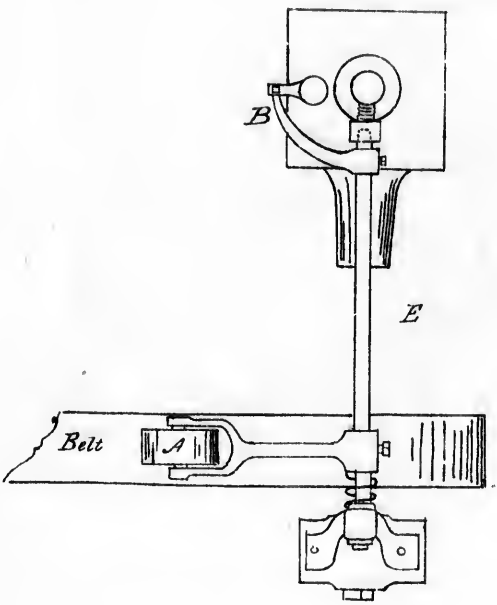
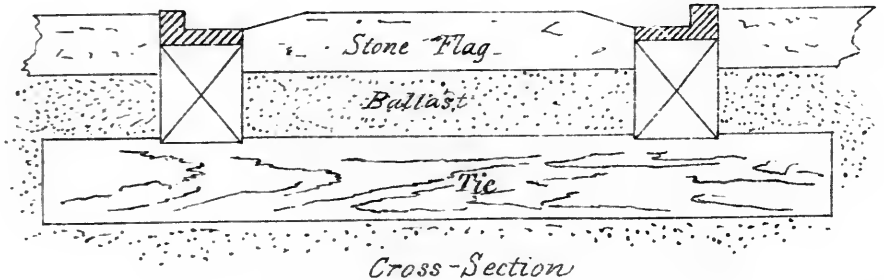


PLATE 11

TRAMWAY IN BOILER ROOM



Cross-Section

APPENDIX II.

Forms for proposed system of carrying on the work in the Engine House:

Form A—Weigh Master's Certificate.

Form B—Boiler Room record (Fireman).

Form C—Monthly Boiler Room record (Chief Engineer).

Form D—Engine Room record.

Form E—Accidents and Repairs.

Form F—Weekly record of Fireman.

Form G—Monthly Duty record of Assistant Engineer.

Form H—Monthly Oil record of Assistant Engineer.

Form I—Chief Engineer's monthly record.

Form J—Chief Engineer's monthly Oil record.

Form K—(Three sheets) Chief Engineer's Annual Report.

Forms A, B and D are to be daily pasted in a book filled with brown paper leaves, designated in the Report as the File Book.

The File Book and Forms C, E and H, together with the Diary, furnish the material from which the information in the remaining forms is compiled.

The greater part of this work is to be done by the Chief Engineer's clerk.

Form A. *Date*.....

WEIGHMASTER'S CERTIFICATE.

Boilers No. 1. Coal delivered.....lbs.
" " 2 " ..... "
" " 3. " ..... "

....
Weighmaster.

DIFFERENCE BETWEEN MEASUREMENT AND WEIGHT.

Boilers.	No. 1.	No. 2.	No. 3.
Weights as per above Certificate	..... lbs.	..... lbs.	..... lbs.
Weights as per measurement	..... "	..... "	..... "
Difference	..... "	..... "	..... "

CORRECTIONS TO BE APPLIED TO MEASUREMENTS IN EACH WATCH.

Boilers.	No. 1.	No. 2.	No. 3.
Watch from 8 a.m to 4 p.m.	..... lbs.	..... lbs.	..... lbs.
" 4 p.m. to 11 p.m.	..... "	..... "	..... "
" 11 p.m. to 8 a.m	..... "	..... "	..... "
Totals	..... "	..... "	..... "

REMARKS.

Form B. *Date*.....

BOILER ROOM RECORD.

Firemen, { .... Watch from .....to.....

No. of Set.	No. of Boiler.	Tally of Barrow Loads.	Total.	Steam Pressure. Hour	Hour	Hour	Feed Water Meter. No.	Reading.
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....c. ft.
.....	.....	.....	.....	.....	.....	.....	.....	..... lbs.
.....	.....	.....	.....	.....	.....	.....	No.	Reading.
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....c. ft.
.....	.....	.....	.....	.....	.....	.....	.....	..... lbs.
								Total.....lbs.

			Average pressure at times of observation.
			Average pressure for whole watch.

Average weight of barrow load .....

.....

Total weight of coal.....lbs.

Weigh Master's correction.....

Correct total weight.....

Total weight of steam .....

Pounds of steam per pound of coal.....

Percentage of error in measurement.....

Bonus for measurement.....

Fine for measurement.....

Weather.

REMARKS.

Form C.

For Month of..... .....

CHIEF ENGINEER'S MONTHLY BOILER ROOM RECORD.

t signifies cleaned tubes
w " washed out.
o " boiler not in use for whole day, but in good order.
o^1_3, o^2_3 signifies boiler not in use for one watch, or two watches.
r signifies boiler not in use for whole day on account of repairs.
r^1_3, r^2_3 signifies boiler not in use for one watch, or two watches.

Day of Month	Set No. 1.				Set No. 2.				Set No. 3.				
	1	2	3	4	1	2	3	4	1	2	3	4	5
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													

Form D.

ENGINE ROOM RECORD.

Date.....

Engineer in Charge.....

Oiler.....

Watch from.....to.....

Engine.	Hour of observation.	Steam gauge.		Vac'm gauge.		Counter.			Water pressure gauge.		Well.		Total average head.		Feed water meter.	
		Reading.	Average.	Reading.	Average.	Reading.	Differences.	Total difference.	Reading.	Average.	Reading.	Average.			Reading.	Difference.
No. 1.....	.....	.....		.....		.....		Reduce here to gallons.	.....	equivalent in feet	.....		Well.....	..... ft.	.....	Reduce to pounds
	.....	.....		.....		.....			.....		.....		Gauge (in feet)	.....ft.	.....	
	.....	.....		.....		.....			.....		.....		Height of gauge.....	.....ft.	.....	
													Total.....	.....ft.		
No. 2.....	.....	.....		.....		.....			.....	equivalent in feet	.....		Well.....	.....ft.	.....	
	.....	.....		.....		.....			.....		.....		Gauge (in feet)	..... ft.	.....	
	.....	.....		.....		.....			.....		.....		Height of gauge	.....ft.	.....	
													Total.....	.....ft.		
No. 3.....	.....	.....		.....		.....			.....	equivalent in feet	.....		Well.....	..... ft.	.....	
	.....	.....		.....		.....			.....		.....		Gauge (in feet)	.....ft	.....	
													Height of gauge.....	.....ft.	.....	
													Total.....	..... ft.		

Engine.	Duty per pound of steam.
1.....	.....ft. lbs.
2.....	..... "
3.....	..... "

RULE.—Multiply total gallons pumped into 10 into total average head and divide by total weight of feed water. The result is the duty in ft. lbs. of work per pound of steam. Calculations to be made here.

Form E.

Date.....

ACCIDENTS AND REPAIRS.

Description, including probable or known cause.			
Action taken.			
Hours lost.			
Cost of repairs, including time of employees, cost of material bought by the Department, and outside account.		$	c.
Remarks.			

Form F.

WEEKLY RECORD OF FIREMAN.

For week ending... .....

Name..... .....

Day of Week	Boilers. Set No.	Duty, Steam per lb of Coal.	Measurement.		
			Per cent. of Error.	Bonus.	Fine.
Sunday					
Monday					
Tuesday					
Wednesday .					
Thursday					
Friday.....					
Saturday.					

Boilers.	Set No. 1.	Set No. 2.	Set No. 3.
Average Duty present Week.....			
Average Duty last Week			
Difference.....			
Per centage of Improvement.....			
Average per cent. of Improvement.....			
Bonus for present Week for economy in Firing.....			

Form G.

MONTHLY DUTY RECORD OF ASSISTANT ENGINEER.

Name..... *For Month of*.....

Day of Month.	Engine No. 1.		Engine No. 2.		Engine No. 3.	
	Length of Watch.	Duty.	Length of Watch.	Duty.	Length of Watch.	Duty.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
Total hours.						
Average Duties.....						

Form H.

MONTHLY OIL RECORD OF ASSISTANT ENGINEER.

For month of..................................

Name..

Description.	Cylinder Oil.		Spindle Oil.		Journal Oil.		Tallow.		Black-lead.		Waste.	
	Date	Gals.	Date	Gals.	Date	Gals.	Date	℔.	Date	℔	Date	℔
Quantities supplied during month and Dates of Supply.												
Total supplied......												
Total on hand......												
Total used..........												

QUANTITIES USED PER HOUR PER ENGINE.

(To be determined from time to time by experiment.)

Engine.	Gals.	Gals.	Gals.	℔	℔	℔
1						
2						
3						

Form H.—Continued.

QUANTITIES USED THIS MONTH BY EACH ENGINES.

Engine.	Hours.	Gals.	Gals.	Gals.	lb	lb	lb
1							
2							
3							
Total							

Form I.

CHIEF ENGINEER'S MONTHLY RECORD.

For Month of .....

Day of Month.	Coal Burned. lbs.	Water Pumped. gals.	Average Water Pressure	Average Levels.			Weather, especially as affecting draught of Boilers.
				Reservoir.	Well.	Lake.	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
Totals and Averages.							

Average Duties of Boilers and Engines.

Boilers.	Engines.	Hours Running.
1.....lbs. of steam per lb. of coal.	1..... Foot lbs. of work per lb. of steam.	
2..... " "	2.....	
3..... " "	3.....	

Form J.

CHIEF ENGINEER'S MONTHLY OIL RECORD.

For Month of.....

QUANTITIES AND COST.

Engine.	Cylinder Oil.	Price.	Amount.	Spindle Oil.	Price.	Amount.	Journal Oil.	Price.	Amount.	Tallow.	Price.	Amount.	Black-lead.	Price.	Amount.	Waste.	Price.	Amount.	Total cost per engine.
			$ c.			$ c.			$ c.			$ c.			$ c.			$ c.	$ c.
1.....																			
2.....																			
3.....																			
Total.....																			

QUANTITIES AND COST OF MISCELLANEOUS MATERIALS USED.

Description.	Quantity—Price.	Amount.	Description.	Quantity—Price.	Amount.
Total.....					

Form K.

CHIEF ENGINEER'S ANNUAL REPORT. *For year..... .....*

Month.	Coal Burned.		Water Pumped.		Average Pressure at Engine House.	Average Levels.			Duties of Boilers.			Duties of Engines per 1,000 lbs. Steam.		
	Total per Month.	Daily Average.	Total per Month.	Daily Average.		Reservoir.	Well.	Lake.	1	2	3	1	2	3
January ...														
February..														
March														
April														
May														
June														
July.....														
August														
September														
October....														
November.														
December.														

Form K.—Continued.

CHIEF ENGINEER'S ANNUAL REPORT.

For year.....

Month.	Boilers.						Engines.						Boilers.			Engines.		
	No. 1.		No. 2.		No. 3.		No. 1.		No. 2.		No. 3.		Cost of Repairs.			Cost of Repairs.		
	Hours in use.	Hours under repair.	Hours in use.	Hours under repair.	Hours in use.	Hours under repair.	Hours in use.	Hours under repair	Hours in use.	Hours under repair.	Hours in use.	Hours under repair.	1	2	3	1	2	3
													$ c.	$ c.	$ c.	$ c.	$ c.	$ c.
January																		
February																		
March																		
April																		
May																		
June																		
July																		
August																		
Sept.																		
October																		
Nov.																		
Dec.																		
Total																		

NOTE.—"Hours in use" includes time of cleaning boilers.

Form K—Continued.

CHIEF ENGINEER'S ANNUAL REPORT. *For year*..... .....

Month.	Cost of Lubricants and Waste used.			Total Cost of Lubricants and Waste used.	Cost of Miscellaneous Material used.	Cost of Miscellaneous Repairs.	Description and Cost of Special Repairs or Alterations not elsewhere stated.
	Engine No. 1.	Engine No. 2.	Engine No. 3.				
	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	
January.							
February.							
March							
April.							
May							
June							
July							
August							
September							
October							
November							
December