

CONSTRUCTION OF SUBSTRUCTURE  
MAYFAIR PUMPING STATION, CHICAGO.

BY

J. T. LUCAS

ARMOUR INSTITUTE OF TECHNOLOGY

1917

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CONSTRUCTION OF SUBSTRUCTURE  
OF MAYFAIR PUMPING STATION  
CITY OF CHICAGO

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A THESIS

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PRESENTED BY

JOHN THOMAS LUCAS

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

CIVIL ENGINEER

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MAY 31, 1917

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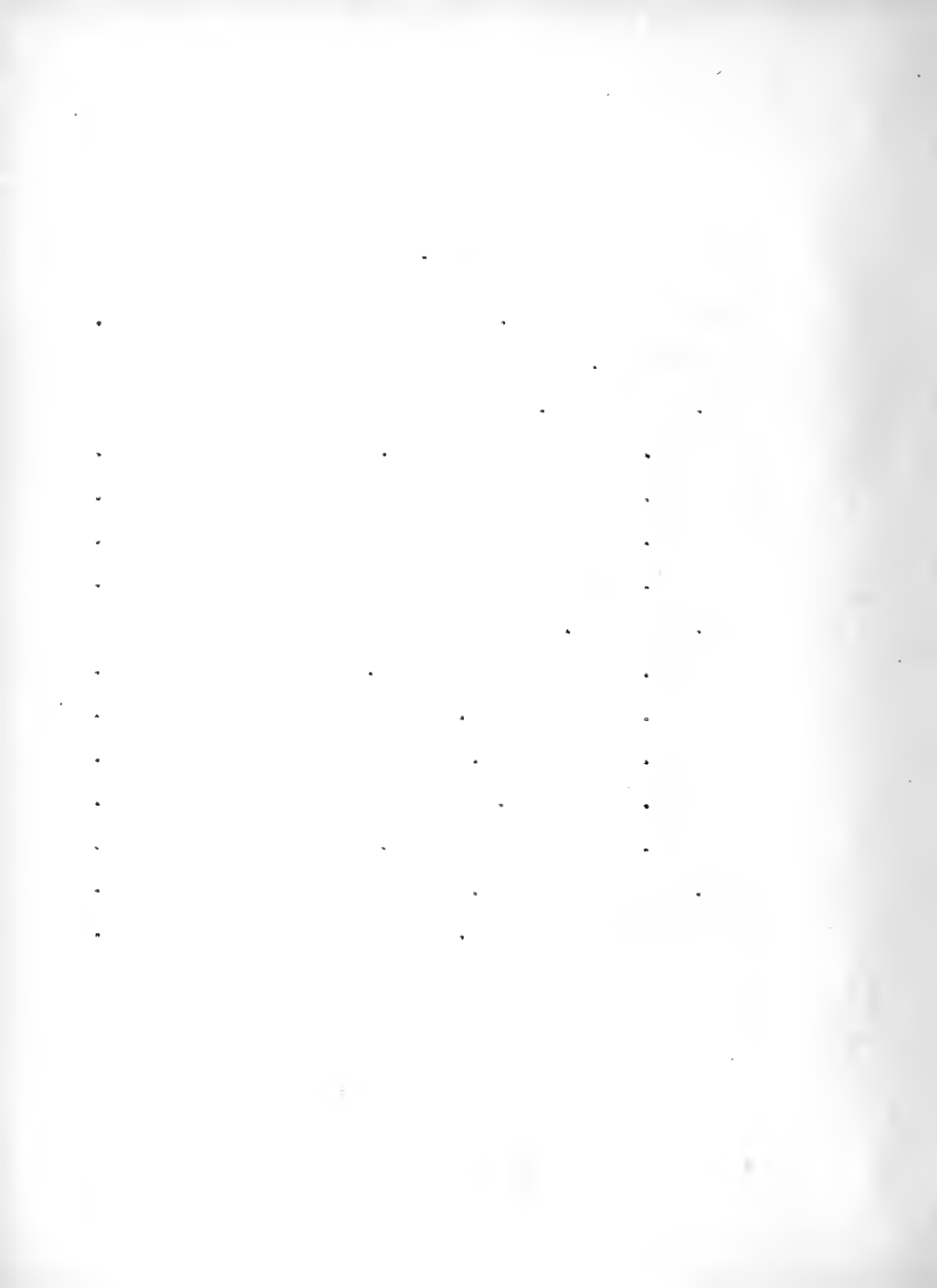
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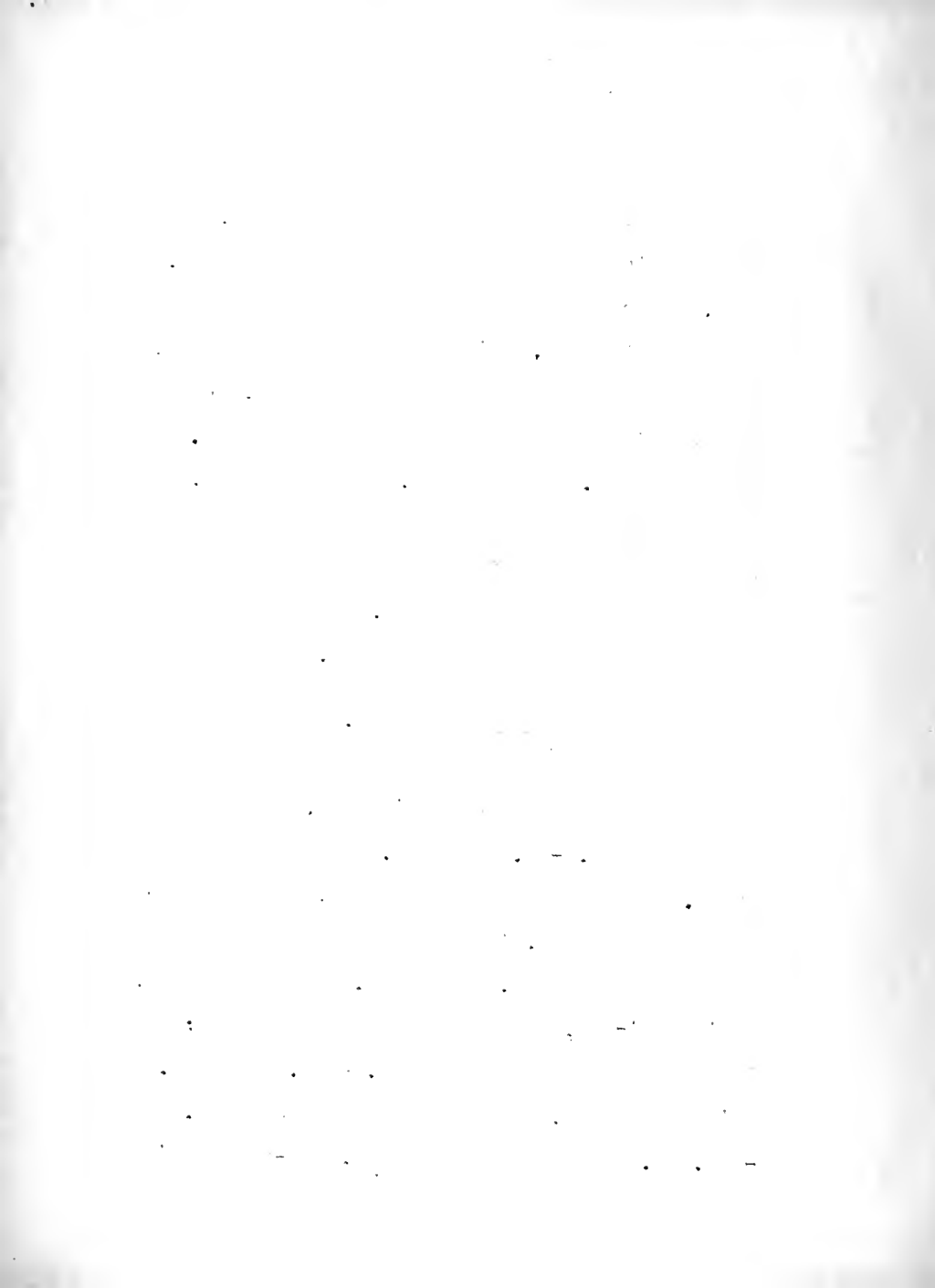
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The Wilson Avenue Tunnel system, the construction of which was commenced in August, 1913, extends from the intake crib in Lake Michigan about 16,250' east of the shore shaft, located at Wilson and Clarendon Avenues, to the new Mayfair Pumping Station at Wilson and N. Lamont Avenues. This station, when completed, will supply the extreme northwest part of the city of Chicago and its adjacent suburbs with water under standard pressure, and under high pressure for high level territory.

#### GENERAL DESCRIPTION.

The building fronts south on Wilson Avenue with a pump room 236' x 60', the floor being at elev. - 7.15' or 38.65' below street grade. At the entrance to station, in the center of south front, there is an office section one story in height, 50' x 31'. The boiler room, 239' x 54'- 3", lies north of the pump room; its basement level is at elev. + 13.92' or 17.58' below grade, and the main floor at elev. + 28.84'. A coal receiving room, 72'- 9" x 70'-



9" is located north of the boiler room with an 18' driveway between these two sections of the station.

A side track, turning south from the C.M.& St.P.Ry., carries coal cars into the receiving room over three receiving hoppers. The coal can be unloaded directly into the hoppers through bottom dump cars, or by means of a grab bucket from an overhead traveling crane; or the coal can be stored in bins on both sides of the track hoppers. Plate No. 1. shows a general layout of the station.

The coal after passing through a crusher under the hoppers is carried south on an apron conveyor to the main bucket conveyor, running east and west in the boiler room four feet north of the boiler fronts. This conveyor supplies a set of enclosed bunkers 175'-6" long, which have a capacity of 1,000 tons. Spouts feed the coal from the bottom of the bunkers, 22' above boiler room floor, to each stoker.

The boilers, fronting north, supply



steam at 175 lbs. pressure through a double header system to the seven pumping engines. They consist of a battery of 6 - 4 pass Edgemoor water tube boilers equipped with Taylor stokers, and have a rating of 500 H.P. each.

The smoke breeching is suspended from the main floor, and enters the central stack from the east and west. The stack is 184'-2" high above boiler room floor, the inside diameter being 8'0" at top and 14'-5" at base, and is supported by four 5'-0" caissons extending to solid rock at elev. - 50.00'.

The water will be pumped by seven pumping engines of a total capacity of 152.5 million gallons in 24 hours. The pumps are of the triple expansion, crank and fly wheel type with mechanically operated suction and discharge valves of Riedler design. The steam ends of both high and standard pressure pumps are alike, but the water ends of the three west pumps are smaller. The three west pumps will each deliver 17.5 million gallons per day against a 200' head,

The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for ensuring transparency and accountability in financial operations. This section also outlines the various methods and tools used to collect and analyze data, highlighting the need for consistency and precision in data entry and reporting.

The second part of the document focuses on the implementation of internal controls and risk management strategies. It details how these measures are designed to prevent fraud, minimize errors, and protect the organization's assets. The text provides a comprehensive overview of the different types of risks faced by the organization and the specific controls put in place to mitigate them. It also discusses the role of management in overseeing these controls and ensuring they are effectively implemented.

The third part of the document addresses the financial performance and budgeting process. It presents a detailed analysis of the organization's financial results, comparing actual performance against the budget and identifying areas of variance. This section also discusses the process of setting financial goals and developing a budget that aligns with the organization's strategic objectives. The text highlights the importance of regular financial reviews and the use of key performance indicators to track progress and make informed decisions.

The fourth part of the document covers the human resources and organizational structure. It describes the current state of the organization's workforce, including the number of employees, their qualifications, and their distribution across different departments. The text also discusses the organization's recruitment and retention strategies, as well as its approach to employee development and training. This section emphasizes the need for a strong organizational culture and effective communication channels to support the organization's success.

The fifth and final part of the document provides a summary of the key findings and recommendations. It reiterates the importance of maintaining accurate records, implementing robust internal controls, and managing financial performance. The text also offers specific recommendations for improving the organization's operations and achieving its long-term goals. The document concludes by expressing confidence in the organization's ability to overcome challenges and achieve sustainable growth.



and the four east pumps will each deliver 25 million gallons per day against a 140' head.

Each pump has two suction nozzles extending south and then down into a common suction tunnel, the flowline of which is 20'-10" beneath pump room floor. All the water entering the pumps passes around the tubes of a surface condenser, and is discharged through four pipes from each pump into the station mains.

There are two discharge mains for the 140' head, one north and one south of the pumps at elev. + 4.00', extending the full length of the station and leaving at the west. They are supported by a series of piers adjacent to the north and south walls of pump room. The two high pressure lines start at about the center of the building, and are supported by saddles on the pipe, leaving also at the west.

Immediately west of the station are two pipe vaults in which the pipes rise to street grade, and change direction to conform with general layout of the water pipe system in street.

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Plate No. 2. indicates the general arrangement of station.

### CONSTRUCTION.

Construction work on foundations was commenced on September 16, 1915.

#### (A). EXCAVATION.

As a preliminary step on the arrival of forces on the ground in April, 1914, at which date work on the Mayfair shaft of the Wilson Avenue tunnel was started, a network of farm tile was laid over the entire area of the proposed station, and connected with the sewer of adjoining territory. This served to remove all surface water, and when ground was broken in the following year the upper strata was comparatively free from moisture.

#### (1). GENERAL EXCAVATION.

The general excavation consisted in removing the upper nineteen feet of earth from the building site by the open cut method. Starting at east end of pump room with a 3/4 yard Cs-good steam shovel, a strip 30 feet in width was

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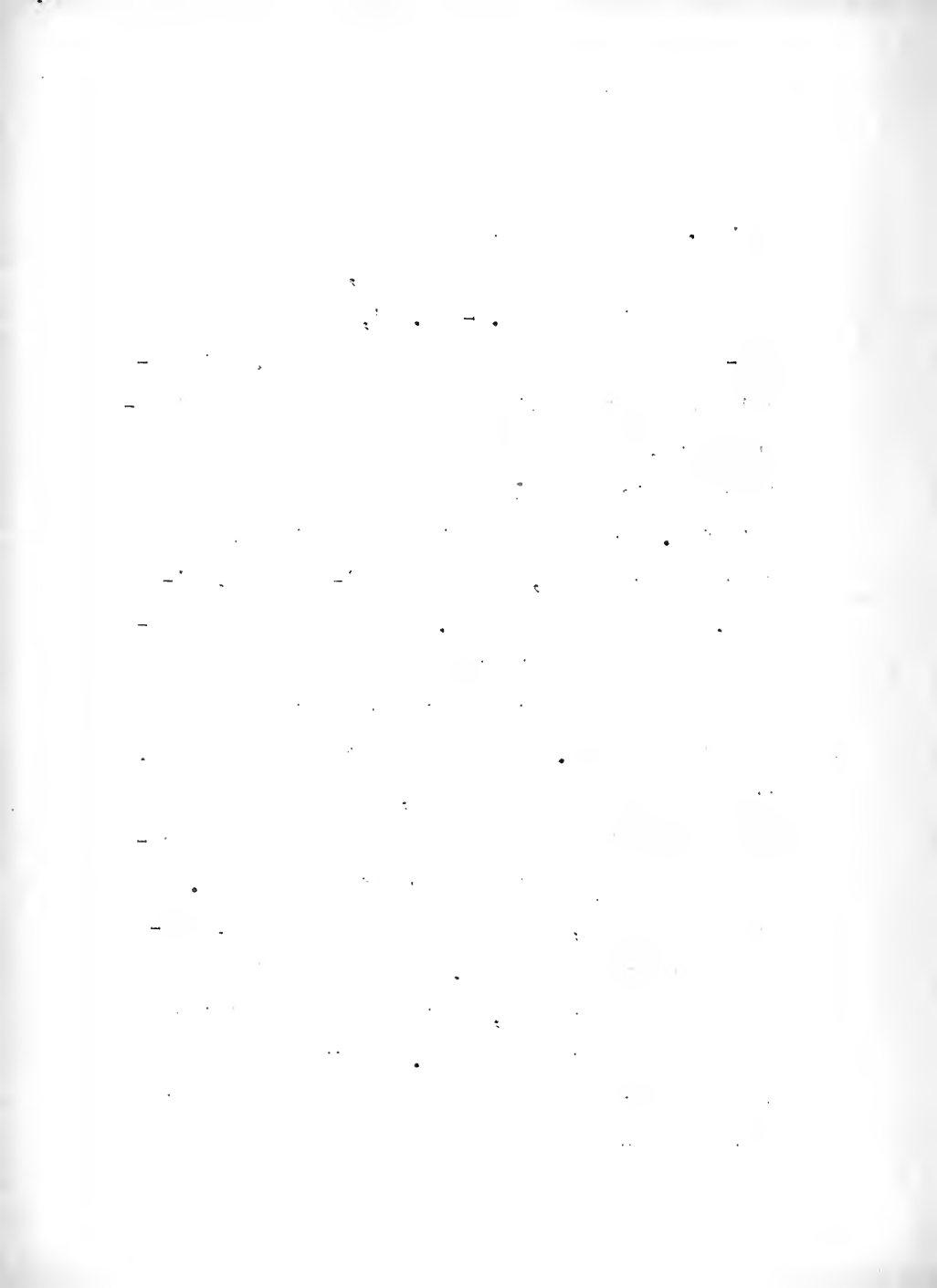
2. The second part outlines the various methods and tools used to collect and analyze data. This includes the use of surveys, interviews, and data mining techniques to gather insights into the organization's performance and the needs of its stakeholders.

3. The third part focuses on the analysis of the collected data. It describes how statistical methods and data visualization tools are used to identify trends, patterns, and areas for improvement. This analysis is essential for making informed decisions and developing effective strategies.

4. The fourth part discusses the implementation of the findings from the analysis. It highlights the importance of communication and collaboration in ensuring that the insights are effectively translated into action. This involves working closely with all levels of the organization to implement changes and monitor progress.

5. The final part of the document provides a summary of the key findings and recommendations. It reiterates the importance of continuous monitoring and evaluation to ensure that the organization remains on track and adapts to changing circumstances. The document concludes by expressing confidence in the organization's ability to achieve its goals through the effective use of data and analytics.

opened. The shovel moved westward on a downward slope for a distance of 100 feet, until it reached bottom of pit at elev.  $\pm$  12.75', the level of sub-soil for boiler room basement floor. This incline was covered with a single layer of 2" planking to afford easy passage for the dump wagons and teams passing over it to receive the excavated material. The shovel itself was provided with four timber floats, each about 8'- 0" long, 4'- 0" wide, and 3" in thickness. These floats were constructed of 3" x 10" pieces of oak bound together and the edges and sides reinforced with angle irons and steel plates. As the shovel traveled forward, its path was laid in advance, the rear float being swung to the front by fastening the attached chains of float to dipper stick of shovel. The dump wagons, of two yard capacity each, moving down runway into pit, were loaded with spoil and hauled to surface, assisted by an auxiliary snatch team of three horses. In like manner the coal receiving room and entire east half of boiler room, and pump room were stripped of the top



layers of soil.

At this stage a more permanent runway in the form of a timber trestle was constructed at the east end of boiler room, and the earth incline removed. The runway was about 25 feet in width, to provide clear passage for two wagons. On the south side a narrow guage track was laid. At the top in center of track was inserted a 24" pulley, over which was run a 3/4" wire cable to electric hoist on surface. Attached to the other end of cable was a small four wheeled truck operating on track, and serving to boost loaded wagons up the incline. The truck replaced the snatch team previously used for the work.

In laying out work for excavation, an additional strip of ten feet outside actual lines of building footings was included to act as berm, and prevent the loose ground from sloughing off, and falling into wall trenches alongside. The banks were not braced except in a few instances, in which shoring was provided to hold up tempor-





ary buildings on top at edge of pit. Care was taken throughout to keep the bottom of pit at same elevation, to insure against water accumulating in pockets. To remove drainage, steam lines were used to bring water to a central steam driven pump, which raised it to the level of surface lines leading to surrounding sewer.

A periodical progress record was kept of work accomplished by steam shovel, as is shown by Plate No. 3. The contract for disposing of spoil was assigned on the basis of loose yardage, measured in wagons. As a means of check, the percentage of swell was computed semi-monthly by measuring the yardage in place excavated and proportioning it to the corresponding loose yardage.

The accompanying photograph No. 1. shows the work in its preliminary stages. In the foreground to the right may be seen the trestle leading from headhouse over shaft and rock removed from the tunnel drift. Some difficulty was encountered in excavating coal receiving room

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry should be supported by a valid receipt or invoice. This ensures transparency and allows for easy verification of the data.

In addition, the document outlines the procedures for handling discrepancies. If there is a difference between the recorded amount and the actual amount received or paid, it is crucial to investigate the cause immediately. This could be due to a clerical error, a missing receipt, or a fraudulent transaction.

The document also provides guidelines for the storage and security of financial records. All records should be stored in a secure location, protected from fire, theft, and unauthorized access. Regular backups should be performed to prevent data loss.

Furthermore, it is recommended to review the records periodically to ensure their accuracy and completeness. This helps in identifying any trends or anomalies that may require further investigation.

Finally, the document stresses the importance of confidentiality. Financial records often contain sensitive information, and it is essential to ensure that this information is not disclosed to unauthorized individuals.

and northwest section of boiler room due to proximity of rock pile, and extreme precautions were taken to secure ground showing any signs of cracking.

This completed the first step by the open cut method of excavation from elev.+ 31.5' to elev.+ 12.75', a depth of 18'- 9".

(2). TRENCH EXCAVATION.

Immediately after the general excavation had been finished by open cut, work was started on the trench excavation for the wall footings of building, beginning in the coal receiving room and following in the wake of the shovel. In the coal receiving room the depth of footings below grade of pit was 7'- 9". These trenches were opened by hand digging and the sides lined with 3" lagging, held in place by 6" x 6" waling pieces and 6" x 6" struts. The soil encountered was very firm and free from moisture, and in no instance was it necessary to drive any lagging in advance.

In the boiler room the footing trenches

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The second part of the document provides a detailed breakdown of the company's assets and liabilities. It lists various categories of assets, such as cash, accounts receivable, and inventory, and compares them against the corresponding liabilities. This section is crucial for understanding the company's overall financial position.

The third part of the document focuses on the company's revenue and profit margins. It analyzes the different sources of income and identifies areas where costs can be reduced to improve profitability. This analysis is essential for making informed decisions about future investments and operations.

The fourth part of the document discusses the company's financial goals and strategies. It outlines the long-term vision and the specific steps that will be taken to achieve it. This section is important for ensuring that all departments are working towards the same objectives.

The fifth part of the document provides a summary of the key findings and recommendations. It highlights the strengths of the company's financial performance and identifies areas for improvement. This summary is intended to provide a clear and concise overview of the entire report.

were 3'- 9" below pit level, necessitating only the ordinary precautions taken in shoring shallow trenches.

The excavated soil was disposed of as in the open cut method by shoveling on dump wagons, and boosting them up incline with truck.

In trench excavation for pump room a problem of more intricate nature presented itself. The pump room, as previously described, embraces an interior area of 236' x 60', and is bounded by four reinforced concrete walls of the counterfort type. The south, east and west walls have a footing penetration to elev.- 13.00' or 25'- 9" below grade of pit, and in each case the footings are 25' in width. The north wall has a footing penetration to elev.- 10.15' or 23'- 2" below grade of pit, and a footing width of 15'- 0".

In the south, east and west wall trenches the first five foot cut was made by steam shovel, with exception of outer six feet, which was left as a factor of safety against the banks



caving in on shovel. In the north wall trench it was found impossible to operate the shovel due to the narrowness of trench, and all material was removed by hand digging.

As practically the same methods were employed in excavating all four trenches in pump room, an explanation of the procedure adopted in digging south wall trench will suffice. Actual hand digging was not begun until after severe cold weather had set in, and to prevent the frost from penetrating into exposed ground, as well as to facilitate construction, three eight hour shifts were organized to carry on the work.

The steam shovel being of service no longer for excavating, its dipper stick was replaced by a 30 foot boom, enabling it to be operated as a derrick. A steel swinging derrick was also placed in east end of pump room, the shovel taking care of west end of building. Beginning at grade of pit, the outer six feet of earth in trench was removed by hand, and loaded into skips of 2 yard capacity each. These skips





were constructed of 3" oak and mounted with chains, which could be fastened to boom of derrick. On being loaded with spoil they were lifted out of trench and elevated to a dumping hopper in pit, under which the wagons passed to receive the disposal. As soon as a section had been excavated to a depth of six feet, the sides were caught with 3" lagging secured with 8" x 10" wales and 8" x 8" struts. The digging was carried on until an additional six foot section was removed, and a similar six foot set of lagging placed. In this manner the excavation progressed in six foot drops, until trench bottom at elev. - 13.00' was reached. Throughout the digging it was found unnecessary to drive any lagging, the ground being of a firm texture and free from quick-sand and excessive moisture. To remove any water accumulating from underground sources or rainfall, steam siphons were extended into trenches, and connected with a steam driven pump on top. This kept the ground in trenches dry and enabled the digging to be prosecuted without interruption. Plate No. 4.



shows the typical bracing used in south wall trench.

(3). CAISSON EXCAVATION.

Referring to Plate No. 5, showing general plan and section of south wall of pump room, it will be seen that the counterforts are centered upon caissons. These caissons, which are of the open well type, extend down past suction tunnel and rest upon hard pan. The method employed in excavating wells consists as follows. A tripod and windlass arrangement was placed over each opening at elev.- 13.00', the level of bottom of wall trench. The core was removed by hand digging in five foot sections, the sides of caisson being well secured by five foot sets of 3" maple lagging held in place by steel rings 2'- 6" apart. In a few instances wet ground and soil resembling quick-sand were encountered, making it necessary to use shorter sets of lagging and also to thoroughly pack the voids behind lagging with hay. The excavated material was raised in buckets to level of trench bottom by hand and emptied into

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry should be supported by a valid receipt or invoice. This ensures transparency and allows for easy verification of the data.

In the second section, the author outlines the various methods used to collect and analyze the data. This includes both primary and secondary data collection techniques. The primary data was gathered through direct observation and interviews, while secondary data was obtained from existing reports and databases.

The third section provides a detailed description of the data analysis process. This involves identifying trends, patterns, and anomalies within the dataset. Statistical tools and software were used to facilitate this process, ensuring that the results are both accurate and reliable.

Finally, the document concludes with a summary of the findings and their implications. It highlights the key insights gained from the study and offers recommendations for future research and practice. The author notes that while the study has provided valuable information, there are still several areas that require further investigation.

skips, which were in turn elevated to surface by derrick and the contents dumped into receiving hopper. From this receptacle the spoil was loaded into wagons and boosted up incline to street grade. The digging for caissons was carried on in three shifts, three men working in each shaft. A daily progress of the work was kept in graphical form, indicating the nature of the ground encountered and other general information necessary in computing costs for excavation. A specimen of these charts is illustrated in Plate No. 6.

A somewhat different method was employed in excavating caissons under chimney in boiler room. The foundations for stack consist of a 19'- 0" square slab of reinforced concrete 6'- 0" in thickness, resting upon four caissons of 5'- 0" diameter penetrating to solid rock at elev.- 50.00'. The digging was started at level of pit elev.+ 12.75' and was prosecuted in five foot sections as in south wall caissons in pump room. An electric hoist was installed about 25'



east of wells and connected by cable with spools over caisson openings. In this manner it was possible to work two diagonally opposite wells at the same time, the spoil buckets being raised to surface of pit by electric power instead of by hand. Plate No. 7. shows diagram of stack caissons and also soil borings taken in vicinity of work.

#### (4). CORE EXCAVATION.

After four walls in pump room had been constructed, there remained a core of earth 218' long, 46' wide and 25'- 9" deep approximating 9200 cu. yards in volume. At this stage the steel swinging derrick and 90 H.P. electric hoist were raised to surface and installed at south east corner of pump room, the mast of derrick resting on top of wall at elev. + 33.00'. The steam shovel was stripped of its boom and the dipper stick put back in place. A double track system of narrow gauge connected by a switching device was laid on surface of core at elev.+ 12.75', and several flat-bottomed wooden dump cars of two yard capacity each brought into service. As

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the shovel cut into the ground it unloaded the excavated material into cars on track alongside. The loaded cars were switched to opposite track and pushed by hand to east end of pump room, at which point the chains of car were caught by hook on fall lines of derrick and elevated to surface. On top alongside east and south walls was laid a timber platform on trestle bents to carry a track of similar guage to that in pit. Over this track was run the loaded cars and the spoil dumped through openings in platform as backfill behind walls. Proceeding in this manner the core was excavated in 12' drops until level of bottom of south wall footing was reached at elev.- 15.00'. In order not to undermine north wall footing, the bottom of which is at elev. - 10.15', a bank of ground ten feet in width was left alongside, the surface being at same elev.- 7.15' as top of footing. Between this bank and edge of south wall footing a series of struts, each consisting of twelve 10" x 10" timbers bound together, was laid at intervals of 31'- 0" coming

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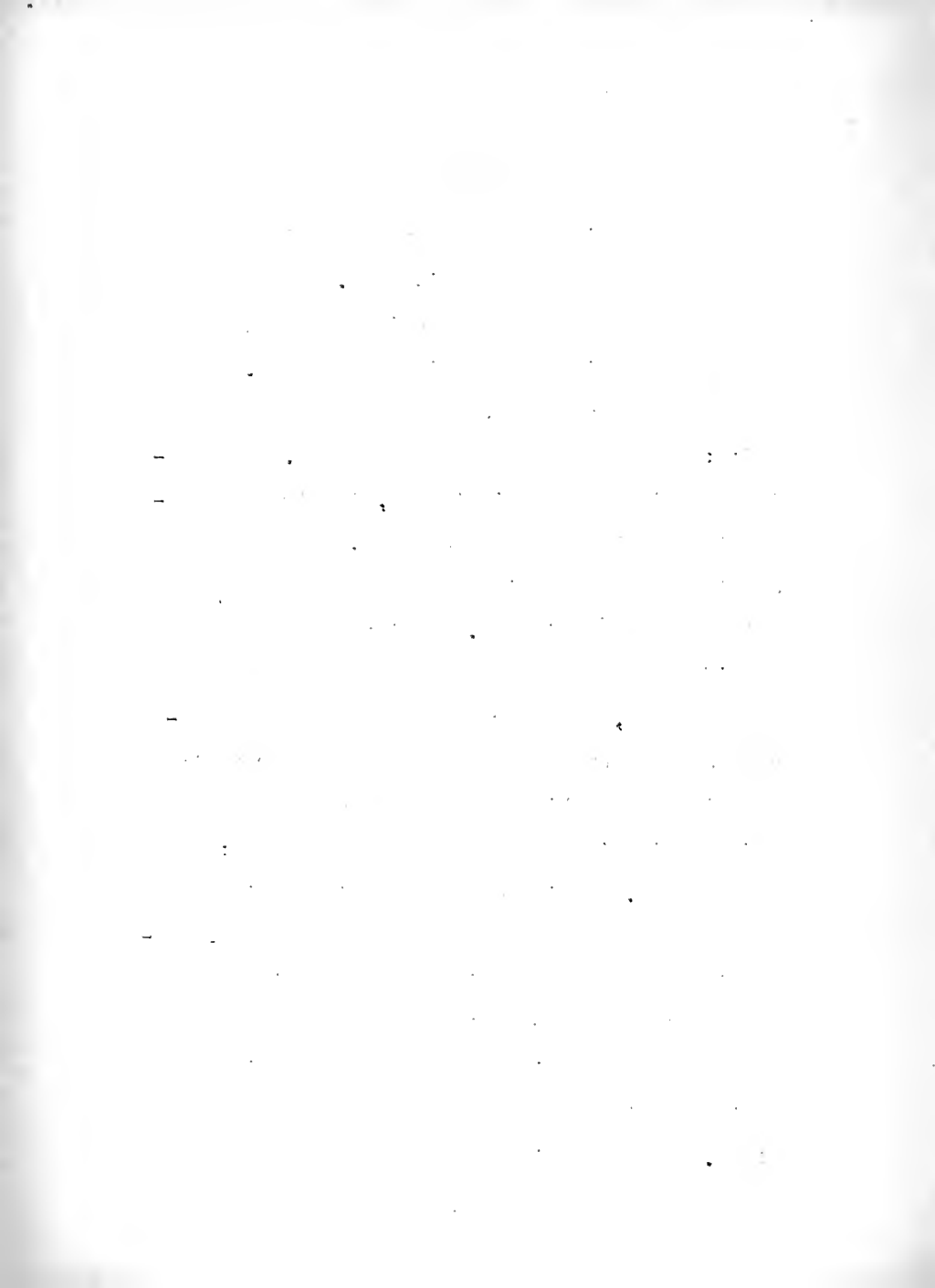
between proposed adjacent engine beds. The purpose of these struts was to counteract any sliding motion on the part of either south or north walls. They were left in place until engine beds had been concreted as well as pump room floor section between north ends of pump foundations and north wall footing. Plate No. 8. shows analysis of procedure in core excavation. This practically completed all excavation for foundations of station.

(B). CONCRETE.-- (1). COAL RECEIVING ROOM.

On the completion of trench excavation in coal receiving room work was immediately started on the foundations. A temporary concreting plant was installed about 100 feet directly north of coal room site, being supplied with material from cars switched from C.M.& St.P. line and delivered on track alongside. The mixer consisted of a chain belt machine of 3/4 yard capacity operated by steam engine. The sand, gravel and cement were wheeled from material piles in barrows up incline and deposited in mixing drum. The con-



crete was received from mixer in buggies and wheeled to edge of foundation pit. A series of chutes placed around pit received the concrete and conducted it to place in foundations. The structure was completed in three separate pours, a 1:2:4 mixture being used throughout. The footing constituted the first step, the trench lagging taking the place of formwork. The second and third pours consisted of the surrounding walls and cross girders. Construction keys were provided in footings and walls after first and second pours, and extreme care was taken to secure a good bond of new concrete by thoroughly sweeping and washing the surface of old concrete and covering it with a layer of grout of 1:2 proportions. In view of the fact that this work was being done during the month of December, precautions were taken against the concrete freezing by covering the forms with canvas after pour had been made and placing salamanders alongside so as to keep the frost out until set had taken place. As an additional measure of safety the



sand and gravel were heated by means of steam lines before being placed in mixer. Plates No. 9. & 10. show sections of formwork and details of walls and girders in coal receiving room.

(2). MIXING PLANT.

A more permanent mixing plant was constructed at this stage to control entire building. The coal receiving room, being divided by cross girders into three separate compartments, offered an excellent location for central plant. The two north sections were separated by a dividing wall of 6" x 6" timbers, and served as storage bins for sand and gravel. The south section was cut off from storage bins by a similar shield of 6" x 6" timbers and subdivided into two hoppers, the bottoms of which were built on an incline of 3" x 8" planks. These hoppers for sand and gravel respectively were fed from storage bins by means of a grab bucket on Browning locomotive traveling crane, operating on material track alongside coal room. The coal bins, each of a storage capacity of 400 cu. yds., were supplied





from material cars switched from main line of C.M.& St.P.Ry. and unloaded by crane. On the west side of bins was situated a cement shed of a storage capacity of 9000bbls. of cement.

Beneath roadway slab and in direct connection with sand and gravel hoppers was located the mixing plant, which consisted of the same equipment as previously used in construction of coal room foundations. The mixer engine however, was operated by steam supplied by 90 H.P. scotch marine boiler on top alongside cement house. A detailed layout of this concreting plant is shown in Plate No.14. The hopper bucket which received sand and gravel through hopper openings regulated by slides, had been previously gauged for a 1:2:4 mixture of concrete, and the marks representing the proper volumes visibly placed on sides. By referring to these indentations the operator was able to regulate the flow of material for each batch. The corresponding amount of cement was set aside in cement house and delivered to bucket below through small grav-



ity chute, on receiving signal from operator. The material, being properly proportioned, was released from bucket through opening in bottom and dumped into mixing drum. The water for each batch was received from water barrel connected with supply pipe, the proper quantity being determined by gauge glass on side of barrel.

The central concreting tower was located in center of roadway slab, the concrete bucket moving through slab opening in 4" x 4" guides fastened to sides of tower. This bucket was fed from mixing drum by means of an apron on mixer and hoisted to top of tower, 50 feet above roadway slab, by electric hoist situated alongside cement house. Two additional towers of a proportional decrease in height were placed, one in boiler room and one in pump room, supporting Ransome concrete chutes. The location of these towers could be changed so as to control any part of structure.

### (3). BOILER ROOM.

The boiler room walls were constructed

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every sale, purchase, and expense must be properly documented to ensure the integrity of the financial statements. This includes keeping receipts, invoices, and bank statements in a secure and organized manner.

The second part of the document focuses on the classification of assets and liabilities. It provides a detailed breakdown of how different types of assets, such as cash, accounts receivable, and inventory, should be recorded and valued. Similarly, it outlines the proper accounting treatment for various liabilities, including accounts payable and long-term debt.

The third part of the document addresses the calculation and reporting of net income. It explains how revenues are recognized and how expenses are matched against them to determine the true profit of the business. This section also discusses the importance of adjusting entries to ensure that the financial statements reflect the economic reality of the business operations.

Finally, the document concludes with a summary of the key principles of accounting and a reminder of the accountant's responsibility to provide accurate and reliable information to the stakeholders. It stresses that transparency and honesty are essential for building trust and ensuring the long-term success of the business.

in two pours, the footings forming the first step and the neatwork section of walls the second. In concreting the footing the trench lagging served as formwork, a construction key being provided to properly bond the wall sections to footings. Moreover the concrete was carefully scrubbed and covered with a 1:2 mixture of grout after forms for walls had been erected, and shortly before second pour was made. For details of walls and formwork in boiler room see Plate No. 11.

The north wall of boiler room was concreted before central concreting plant had been installed, and the same methods were employed in pouring as in constructing coal receiving room foundations. The east and west exterior and interior walls of boiler room were concreted by means of the main plant then under operation. Throughout a 1:2:4 mix was used for walls and footings of this part of station. As the work was being carried on in cold weather the same precautions were taken against the concrete freez-



ing as employed in pouring coal room walls.

(4). PUMP ROOM.

Immediately after the bottom of caissons under south wall of pump room had been belled out, the lower sections, the sides of which were unprotected by lagging, were concreted so as to secure the ground. The upper sections were poured at a later date when several wells were ready, together with a four inch layer over the entire bottom of wall trench to serve as a bed for footing reinforcement. This facilitated the laying of the heavy steel bars specified, and kept the reinforcing comparatively free from contact with any foreign matter, such as mud and slime which otherwise might have accumulated in trench bottoms due to the thawing of the frozen ground together with the spring rains. In order to guard against a horizontal joint in footing in plane of reinforcing this four inch bed was thoroughly cleaned and covered with a layer of grout before next pour was started. This precaution was taken in all cases where it was neces-

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sary for horizontal joints in structure. In view of the fact that the wall section between counterforts was designed as a continuous slab, all vertical construction joints were made at the quarter point in span, this being theoretically the point of zero bending moment. By a judicious handling of the trench shoring, as illustrated in Plate No. 13., it was possible to bring pump room wall sections to top, a distance of 40 feet, without leaving any holes in structure for bracing.

This method, although involving some additional expense due to reshoring against walls, justified itself by the results obtained. No serious leaks were encountered in all four walls of pump room, practically a water-proof structure being secured which was the chief object sought after in its construction. The formwork for these walls was of a similar nature to that employed in coal receiving room and boiler room walls, sections of which are shown in Plate Nos. 10 & 11. This work was done during the early

The following table shows the results of the experiment. The first column shows the number of trials, the second column shows the number of correct responses, and the third column shows the percentage of correct responses. The fourth column shows the standard error of the mean. The fifth column shows the confidence interval. The sixth column shows the p-value. The seventh column shows the effect size. The eighth column shows the power of the test.

Number of trials	Number of correct responses	Percentage of correct responses	Standard error of the mean	Confidence interval	p-value	Effect size	Power of the test
10	7	70%	1.08	68.2% - 71.8%	0.0045	0.63	0.80
20	14	70%	0.77	68.2% - 71.8%	0.0045	0.63	0.80
30	21	70%	0.60	68.2% - 71.8%	0.0045	0.63	0.80
40	28	70%	0.47	68.2% - 71.8%	0.0045	0.63	0.80
50	35	70%	0.38	68.2% - 71.8%	0.0045	0.63	0.80
60	42	70%	0.31	68.2% - 71.8%	0.0045	0.63	0.80
70	49	70%	0.26	68.2% - 71.8%	0.0045	0.63	0.80
80	56	70%	0.22	68.2% - 71.8%	0.0045	0.63	0.80
90	63	70%	0.19	68.2% - 71.8%	0.0045	0.63	0.80
100	70	70%	0.16	68.2% - 71.8%	0.0045	0.63	0.80

The results of the experiment show that the percentage of correct responses is consistently 70% across all trial numbers. The standard error of the mean decreases as the number of trials increases, indicating that the results are becoming more stable. The confidence interval and p-value remain constant, suggesting that the results are statistically significant. The effect size and power of the test are also constant, indicating that the experiment is well-powered.

spring and part of the summer following. The proportions of 1:2:4 were adhered to in pouring caissons, footings and walls throughout this part of structure. Plate No. 12. shows a section of south wall of pump room. The same methods were followed in constructing north, east and west walls as previously explained.

This completed the concreting in engine room until core of earth from elev.+ 12.75, to elev.- 13.00' was removed. Work was then resumed on the engine beds, each of the seven being concreted in one pour, a 1:2:4 mix being used. The pump room floor, condenser piers, pipe piers and other foundations of smaller volume were taken in order until concrete work in this section of building was entirely finished.

(5). CHIMNEY FOUNDATION.

As soon as stack caisson excavation had been completed for two diagonally opposite wells, the lower sections were concreted, and work started on other two wells. The lower sections of these were poured together with upper



sections of first pair of caissons. The slab, resting on caissons was constructed in one pour, a 1:2:4 mix being used throughout.

(C). PLANT EQUIPMENT.

In so far as possible in the course of work on the pumping station, the policy adopted was to employ machinery in the handling of all materials, and to carry out the actual construction on building.

A Browning locomotive crane of 15 ton capacity served to handle all material cars received from C.M.& St.P.Ry. alongside building site. By means of a grab bucket all sand and gravel were unloaded from cars into storage bins in coal room foundations, and the material hoppers supplied from storage bins in same fashion. The grab bucket could be replaced by a hook and chain, and thus enable the crane to act as a derrick in lifting or moving heavy objects such as structural steel, stone, granite and other miscellaneous material. A second track was installed at a later date alongside east walls of

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in the context of public administration and government operations. The text notes that without reliable records, it becomes difficult to track the flow of funds, resources, and information, which can lead to inefficiencies and potential misuse of public resources.

2. The second part of the document outlines the various methods and tools used to collect, store, and analyze data. It mentions the use of spreadsheets, databases, and specialized software to manage large volumes of information. The text also discusses the importance of data security and privacy, highlighting the need for robust protocols to protect sensitive information from unauthorized access and breaches. Additionally, it touches upon the role of data in decision-making, suggesting that well-maintained records can provide valuable insights into trends and patterns that inform policy and operational choices.

3. The third part of the document addresses the challenges associated with data management and record-keeping. It identifies common issues such as data redundancy, inconsistency, and the risk of data loss. The text suggests several strategies to mitigate these challenges, including regular data audits, the implementation of backup procedures, and the use of cloud-based storage solutions for enhanced accessibility and security. It also emphasizes the importance of training staff on proper data handling practices to ensure the integrity and reliability of the records.

4. The final part of the document provides a summary of the key points discussed and offers recommendations for future improvements. It reiterates the significance of a systematic approach to record-keeping and data management, suggesting that organizations should invest in the necessary infrastructure and personnel to ensure the long-term success of their record-keeping efforts. The text concludes by encouraging a culture of transparency and accountability, where accurate records are not just a requirement but a cornerstone of effective governance and public service.

boiler and pump rooms, which made it possible for crane to operate in that vicinity and thus control these sections of the station. As a typical instance of the adaptability of this machine, the following case is cited.

After excavation had been completed in pump room, the steel swinging derrick was dismantled and elevated to surface by crane, at which level it was then installed. The steam shovel was raised in like manner from pit, a lift of approximately 12 tons being made through a vertical distance of nearly 50 feet. During superstructure construction the crane was used in erection as well as handling materials.

The uses of the steel swinging derrick have been mentioned in previous description of methods of excavation. On being no longer of service in pump room pit, it was elevated to surface and there employed in conjunction with the locomotive crane.

The Osgood steam shovel was used principally in straight open cut excavation, although





it was also employed in the role of a derrick in pump room excavation the dipper stick being replaced by boom. After foundation excavation had been completed its period of service was ended, and it was raised to street grade from pump room pit and moved to another construction site.

Electric hoists of various ratings were used to carry on construction work. A 90 H.P. machine was used continuously in conjunction with swinging derrick. Hoists of smaller capacity were employed in excavating chimney wells, and boosting dump wagons up runway from pit, as described in article on open cut excavation.

The steam supply for building was obtained from 90H.P. scotch marine boiler, installed directly west of coal room site. The concrete mixer engine received its steam supply from this boiler as well as the drainage pumps in boiler and pump rooms. Pipe lines were connected to the main supply in thawing out frozen

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sand and gravel and also to heat concreting materials in cold weather.

Directly north of coal room and east of rock pile was located a plot of ground which served for storage of materials, such as reinforcing steel, lumber for bracing and formwork, structural steel, brick, stone and other building products. Photograph No.1. shows view of material yard.

#### ORGANIZATION AND COSTS.

Construction work on the substructure of the Mayfair Pumping Station was prosecuted on the day labor plan. All building material was ordered either directly from job site in small assortments, or let out by contract in large lots through main office. Labor, skilled and common, was obtained through civil service commission, the men being certified to their places of work when requisition was made from job by engineer in charge. The wage rates were in accordance with the union scale and the working hours from 8:00 A.M. to 4:30 P.M.

Year	1888	1889
1	100	100
2	100	100
3	100	100
4	100	100
5	100	100
6	100	100
7	100	100
8	100	100
9	100	100
10	100	100
11	100	100
12	100	100
13	100	100
14	100	100
15	100	100
16	100	100
17	100	100
18	100	100
19	100	100
20	100	100
21	100	100
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92	100	100
93	100	100
94	100	100
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96	100	100
97	100	100
98	100	100
99	100	100
100	100	100

The following system was adopted in recording all charges and costs of work.

Each name on the payroll was represented by a numbered brass check. On reporting for work the men received their checks at the timekeeper's office, and on leaving returned the checks to same office. No man was permitted to work without a check. A man failing to return his check at the close of the day's work was given time up to the last hour he was noted in field by timekeeper.

A daily list, called a check sheet, was made, showing numbers of checks which had been called for at the beginning of the day's work. On the first trip around job in morning these numbers were located and checked off by timekeeper on this sheet. A similar trip was made in the afternoon and the same procedure followed. The hours and rates of each employe were entered on sheet opposite corresponding number, and turned in to payroll clerk about 8:00 A.M. the following day.

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The distribution of time was also made by field timekeeper, who was constantly on the outside and in contact with work. The time of each man was charged against the proper class and location of work on a field distribution sheet. These charges were classified by symbols in accordance with schedule as submitted on Plates No. 15, 16 and 17. All special occurrences as to the beginning and completion of work, etc. were recorded, the sheet practically constituting a field diary. This sheet was delivered to payroll clerk with check sheet.

The office distribution consisted in bringing together all charges of same symbol, from which the daily force account was made. This sheet contained all charges properly classified as well as unit costs of work and other information bearing on the job. A copy of each daily force account was sent to main division office together with a cost sheet at the end of each period, of approximately two weeks in length, which consisted of a general summary of all money

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in the context of public administration and financial management. The text suggests that organizations should implement robust systems to capture and store data, ensuring that it is accessible and secure.

2. The second part of the document addresses the challenges associated with data management and analysis. It highlights the need for skilled personnel who can effectively interpret the data and extract meaningful insights. The text also discusses the importance of data security and privacy, noting that organizations must take appropriate measures to protect sensitive information from unauthorized access and misuse.

3. The third part of the document focuses on the integration of technology into organizational processes. It argues that leveraging modern tools and platforms can significantly enhance efficiency and productivity. The text provides examples of various technologies, such as cloud computing, artificial intelligence, and data analytics, and discusses how they can be applied to different aspects of an organization's operations.

4. The fourth part of the document discusses the importance of continuous learning and development. It emphasizes that organizations must invest in training and development programs to ensure that their workforce remains up-to-date with the latest industry trends and technologies. The text also discusses the importance of fostering a culture of innovation and experimentation, where employees are encouraged to explore new ideas and approaches.

5. The fifth part of the document concludes by summarizing the key findings and recommendations. It reiterates the importance of accurate record-keeping, effective data management, technological integration, and continuous learning. The text also provides a call to action, urging organizations to take immediate steps to address the identified challenges and opportunities.



expended for labor and material for the foregoing period.

The personnel of overhead organization was as follows:

Engineer in charge.

General foreman.

Junior engineer.

Rodman - instrumentman.

Rodman - draftsman.

Field time clerk.

Cost clerk.

Material clerk.

Payroll clerk.

Messenger.

The work was carried on under the supervision of Mr. Henry W. Clausen, Engineer of Water Works Construction. Mr. F.C. Martini is the engineer in local charge of construction, and the writer is first assistant to engineer in charge.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part outlines the various methods and tools used to collect and analyze data. This includes the use of surveys, interviews, and focus groups to gather qualitative information, as well as the application of statistical software for quantitative analysis.

3. The third part details the process of identifying trends and patterns in the data. This involves comparing results across different time periods and departments to uncover areas of strength and weakness.

4. The fourth part focuses on the interpretation of the findings and the formulation of recommendations. It stresses the need to base decisions on evidence and to consider the potential impact of any proposed changes.

5. The final part of the document provides a summary of the key findings and a call to action for the organization to implement the recommended strategies and improve its overall performance.

The following unit costs of work are submitted.

EXCAVATION. ( Steam Shovel.)

General Excavation and Engine Room Core.

39,750 cu. yds. @ \$ .35 per cu. yd.

EXCAVATION. ( Hand Digging.)

South, West and East Wall Trenches of Eng. Room.

9,000 cu. yds. @ \$1.70 per cu. yd.

North Wall Trench of Eng. Room.

2,882 cu. yds. @ \$1.50 per cu. yd.

Caissons under South Wall of Engine Room.

777 cu. yds. @ \$4.29 per cu. yd.

Caissons under Chimney of Boiler Room.

230 cu. yds. @ \$4.20 per cu. yd.

BRACING & LAGGING.

South, West and East Wall Trenches of Eng. Room.

9,000 cu. yds. @ \$1.22 per cu. yd.

North Wall Trench of Eng. Room.

2,882 cu. yds. @ \$1.21 per cu. yd.

Caissons under South Wall of Eng. Room.

777 cu. yds. @ \$1.99 per cu. yd.



**BRACING & LAGGING.**

Caissons under Chimney of Boiler Room.

230 cu. yds. @ \$1.95 per cu. yd.

**ELEVATING & HOISTING.**

Core of Engine Room.

9,000 cu. yds. @ \$ .46 per cu. yd.

South, West and East Wall Trenches of Eng. Room.

9,000 cu. yds. @ \$ .77 per cu. yd.

North Wall Trench of Eng. Room.

2,882 cu. yds. @ \$ .81 per cu. yd.

**DISPOSAL. ( Including Backfill.)**

Wall Trenches of Eng. Room.

11,882 cu. yds. @ \$ .93 per cu. yd.

**FORMWORK.**

Walls of Engine Room.

69,100 sq. ft. @ \$ .17 per sq. ft.

Walls of Boiler Room.

20,100 sq. ft. @ \$ .17 per sq. ft.

Walls and Girders of Coal Receiving Room.

11,300 sq. ft. @ \$ .17 per sq. ft.

Engine Foundations.

9,570 sq. ft. @ \$ .17 per sq. ft.



**CONCRETE. ( Mixing & Placing.)****Engine Room Walls.**

5,360 cu. yds. @ \$ .75 per cu. yd.

**Boiler Room Walls.**

1,229 cu. yds. @ \$ .75 per cu. yd.

**Coal Receiving Room Walls and Girders.**

569 cu. yds. @ \$ .75 per cu. yd.

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- Plate No. 2. Transverse Section of Pumping Station.
- Plate No. 3. Excavation Progress Chart.
- Plate No. 4. Trench Bracing for Pump Room Walls.
- Plate No. 5. Caissons for South Wall of Pump Room.
- Plate No. 6. Progress Diagram for Caisson Excavation.
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- Plate No.15. General Key to Cost Schedule.
- Plate No.16. Numeral Schedule for Excavation.
- Plate No.17. Numeral Schedule for Concrete.

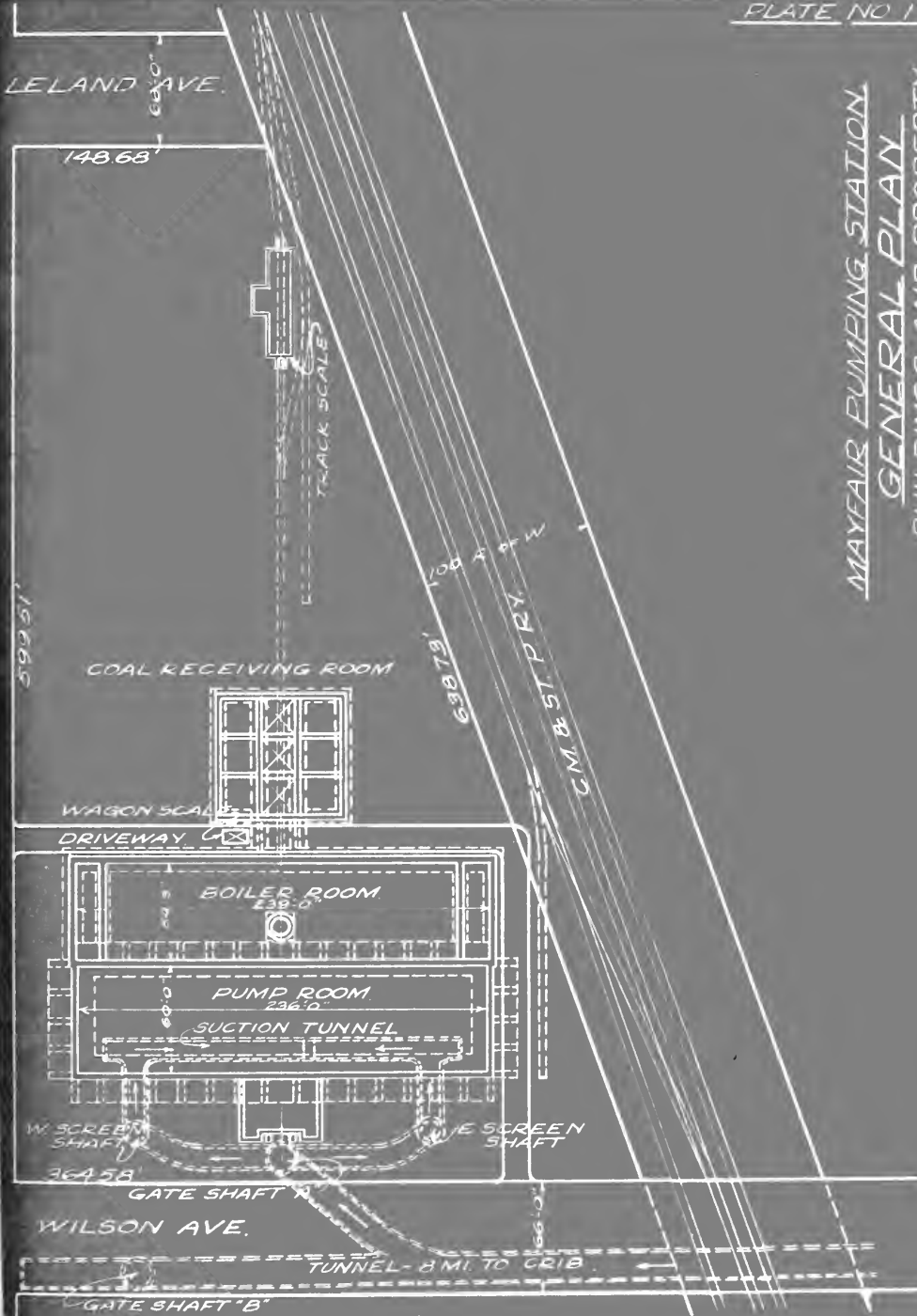
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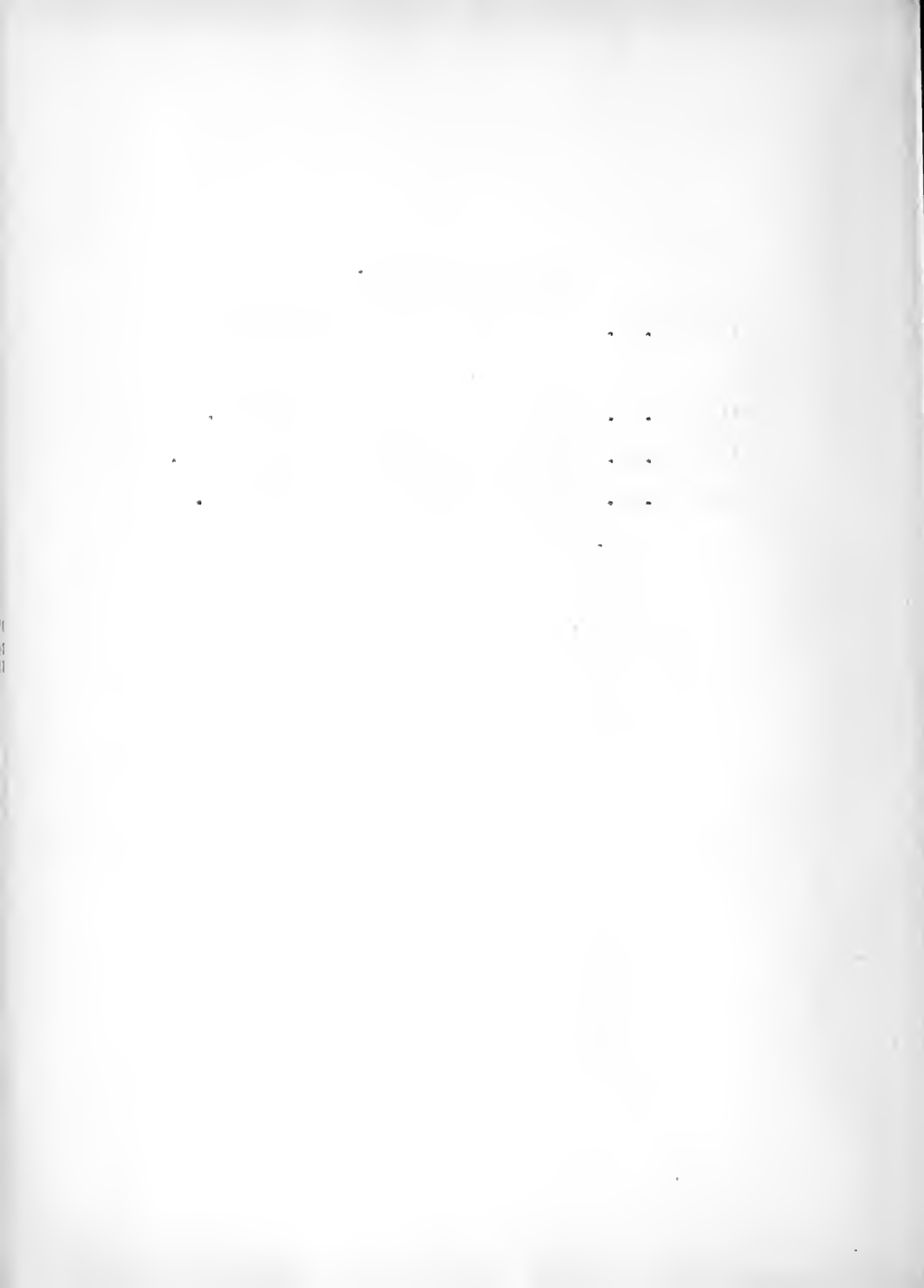
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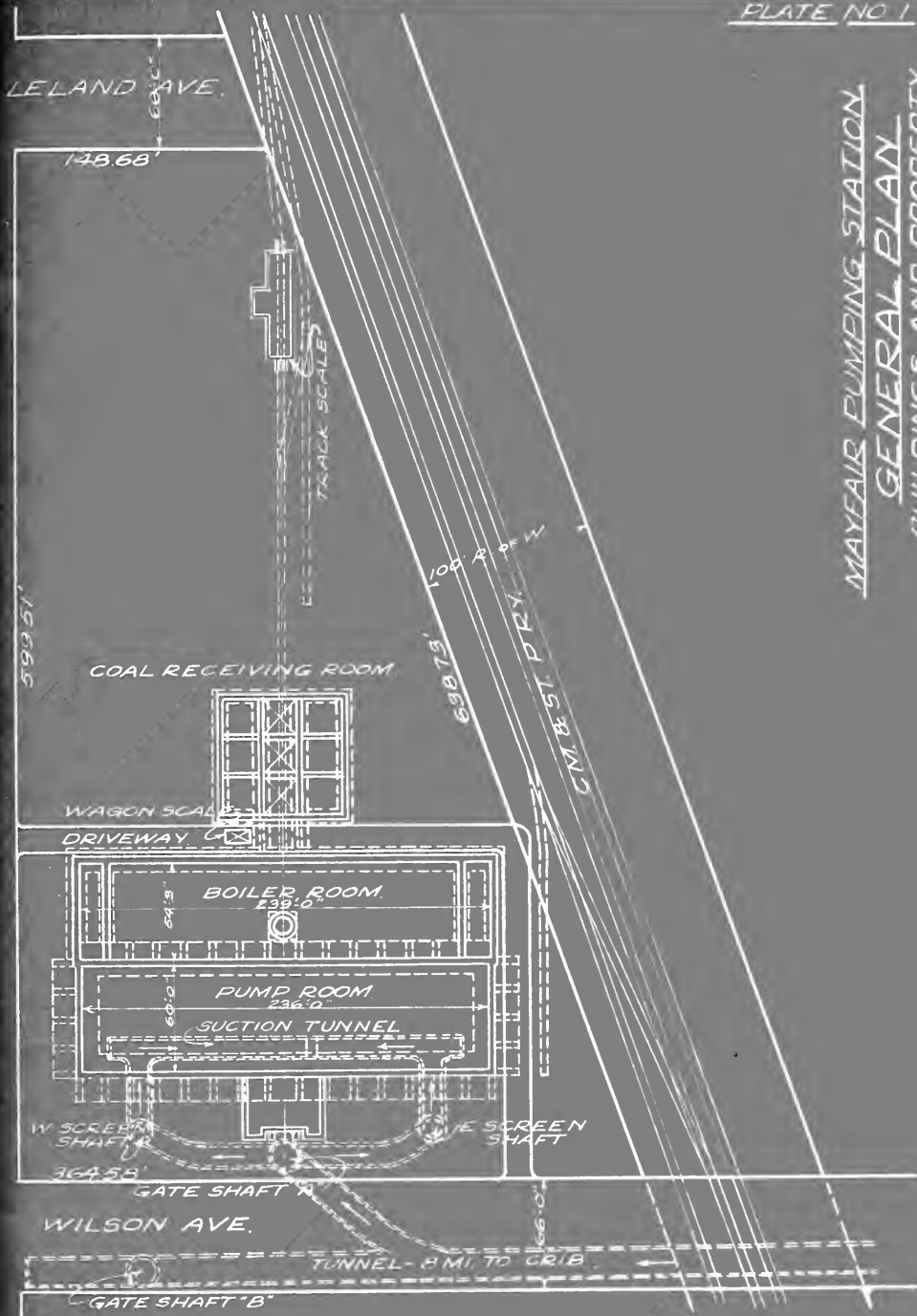
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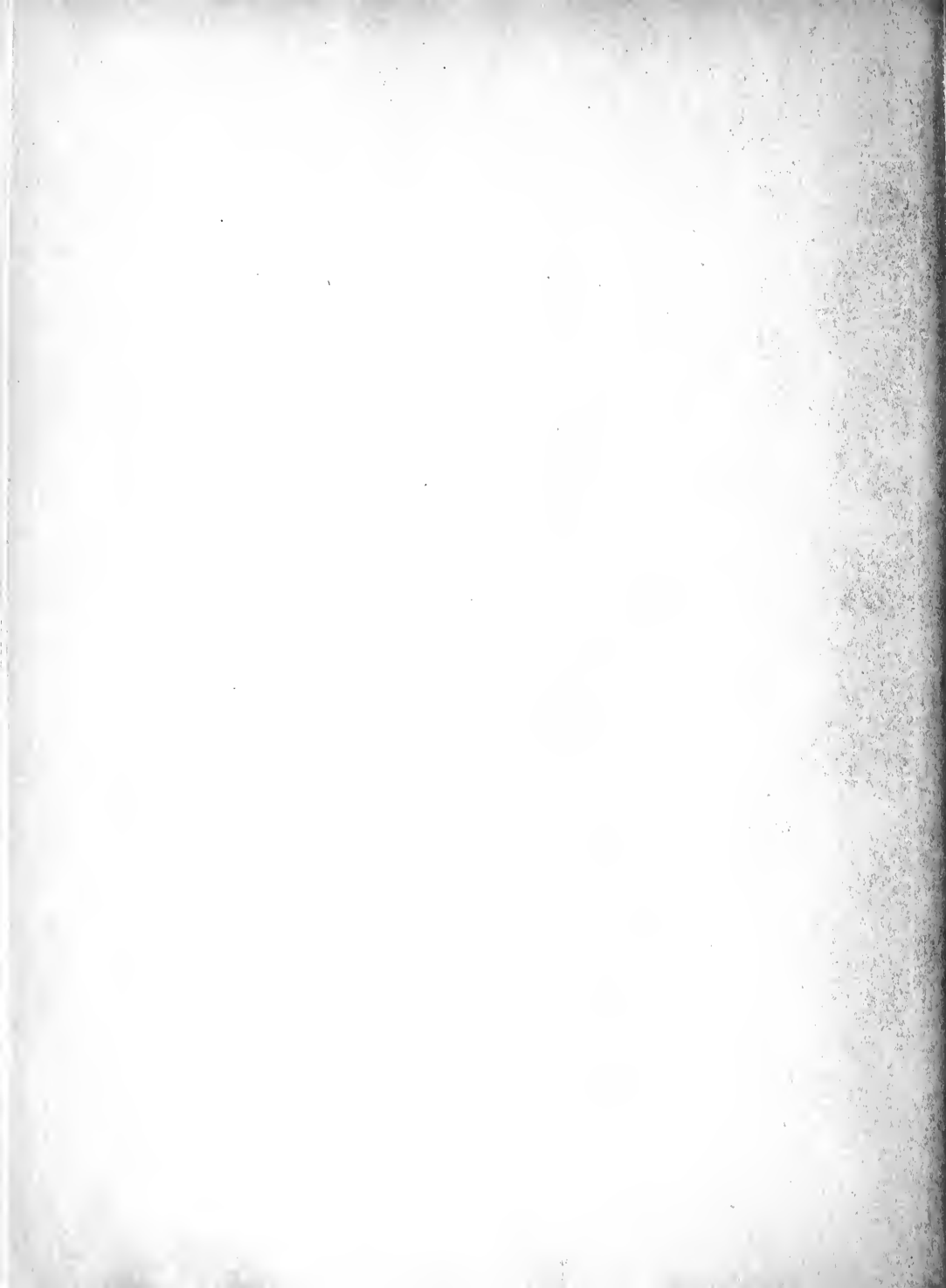
MAYFAIR PUMPING STATION  
GENERAL PLAN  
BUILDINGS AND PROPERTY.





MAYFAIR PUMPING STATION  
GENERAL PLAN  
BUILDINGS AND PROPERTY



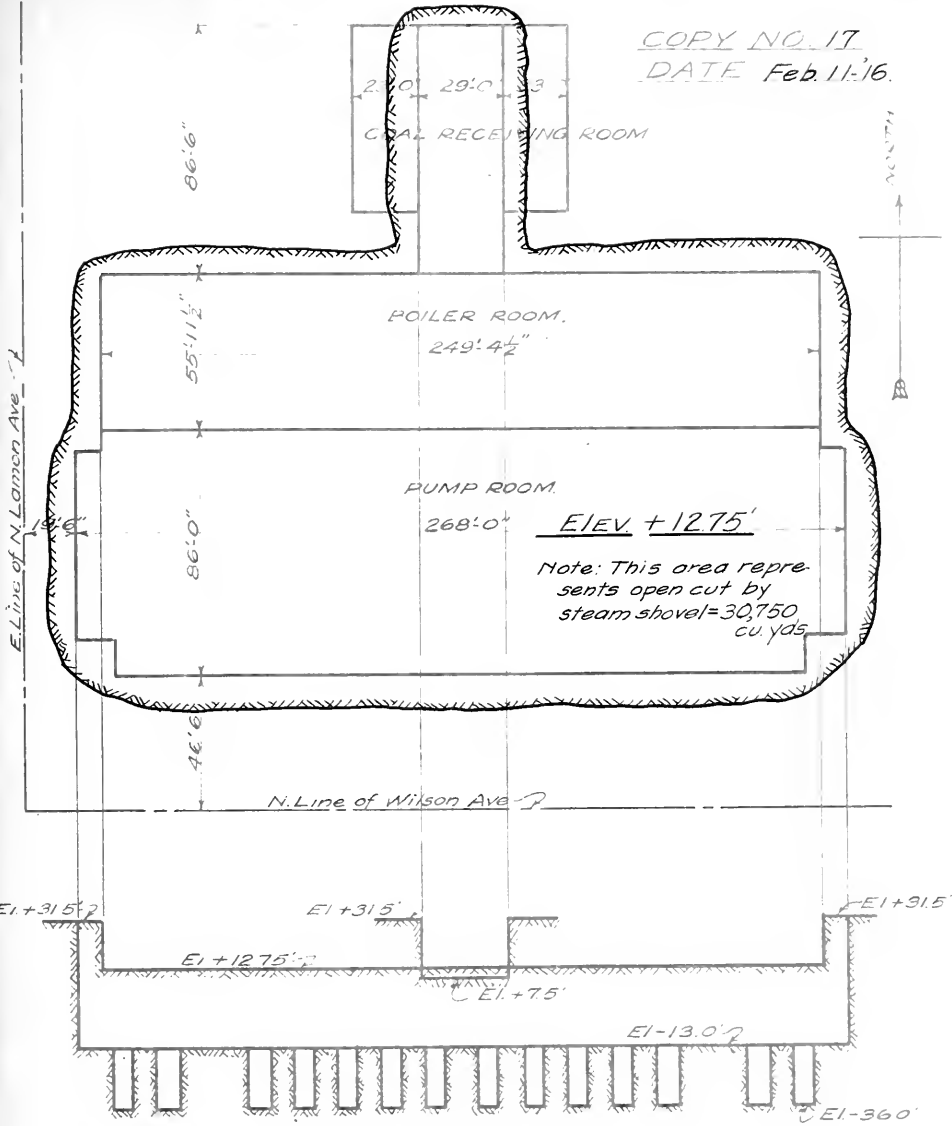






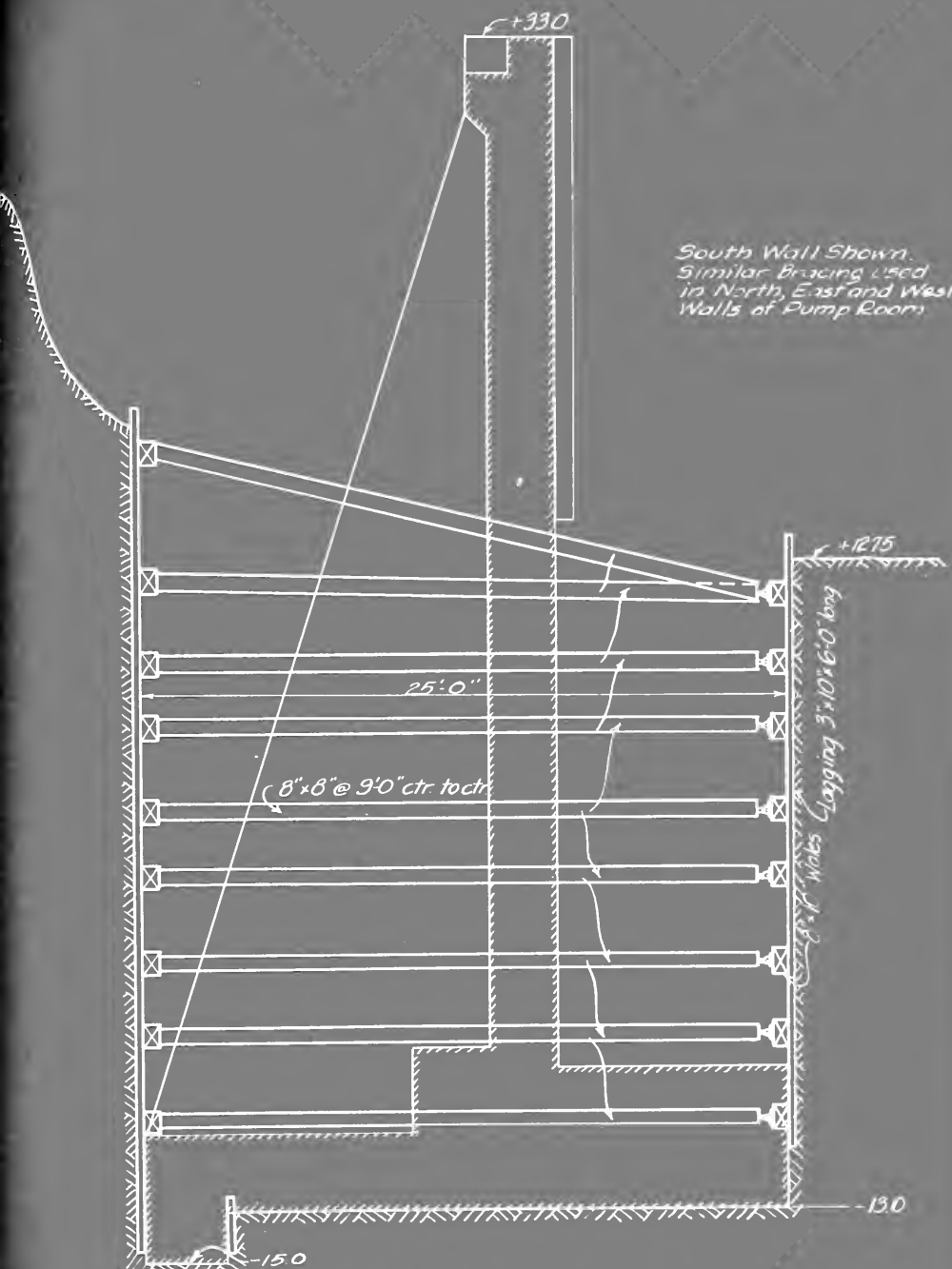


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DATE Feb. 11, 1916.



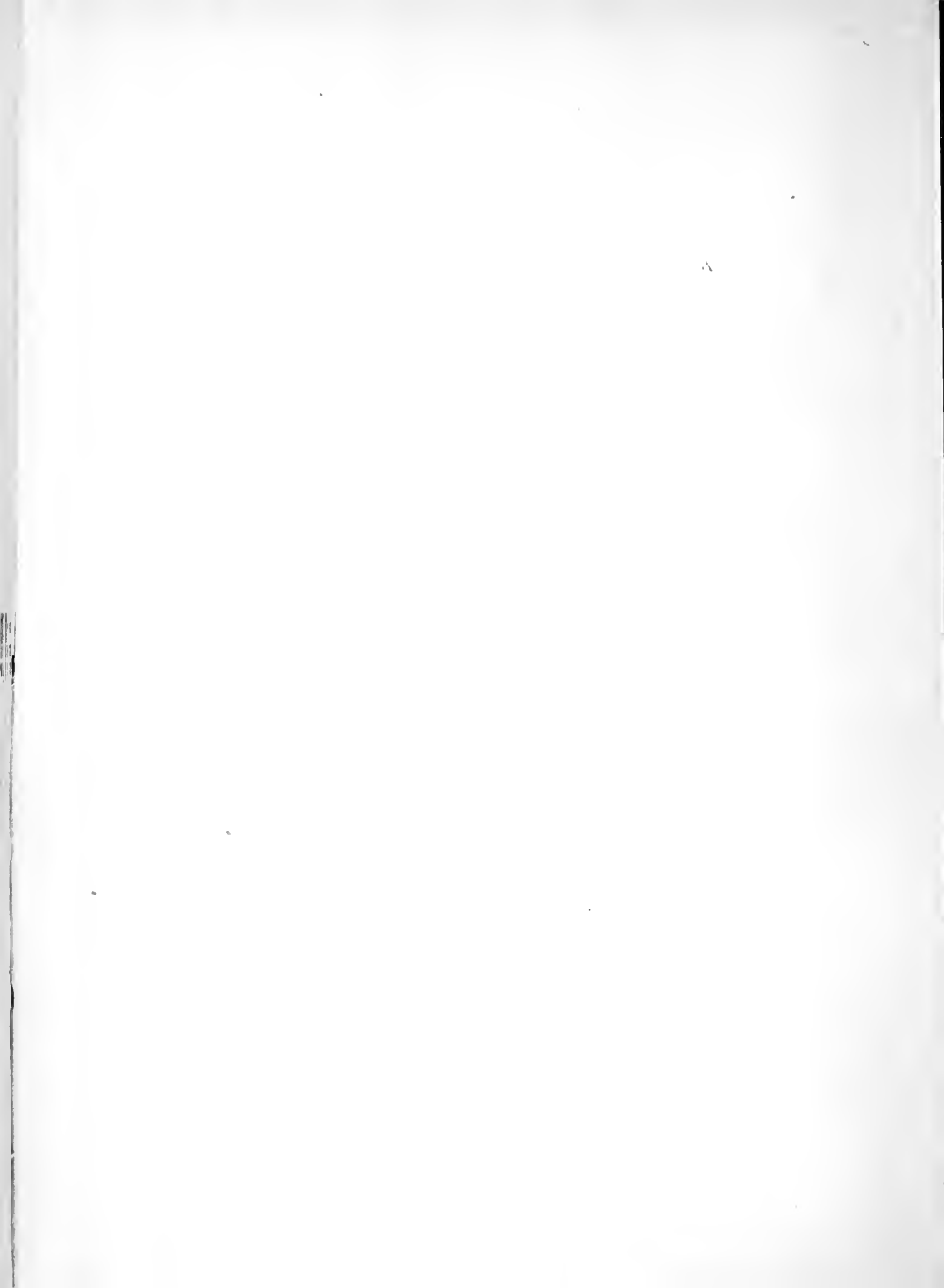
MAYFAIR PUMPING STATION.  
EXCAVATION PROGRESS CHART





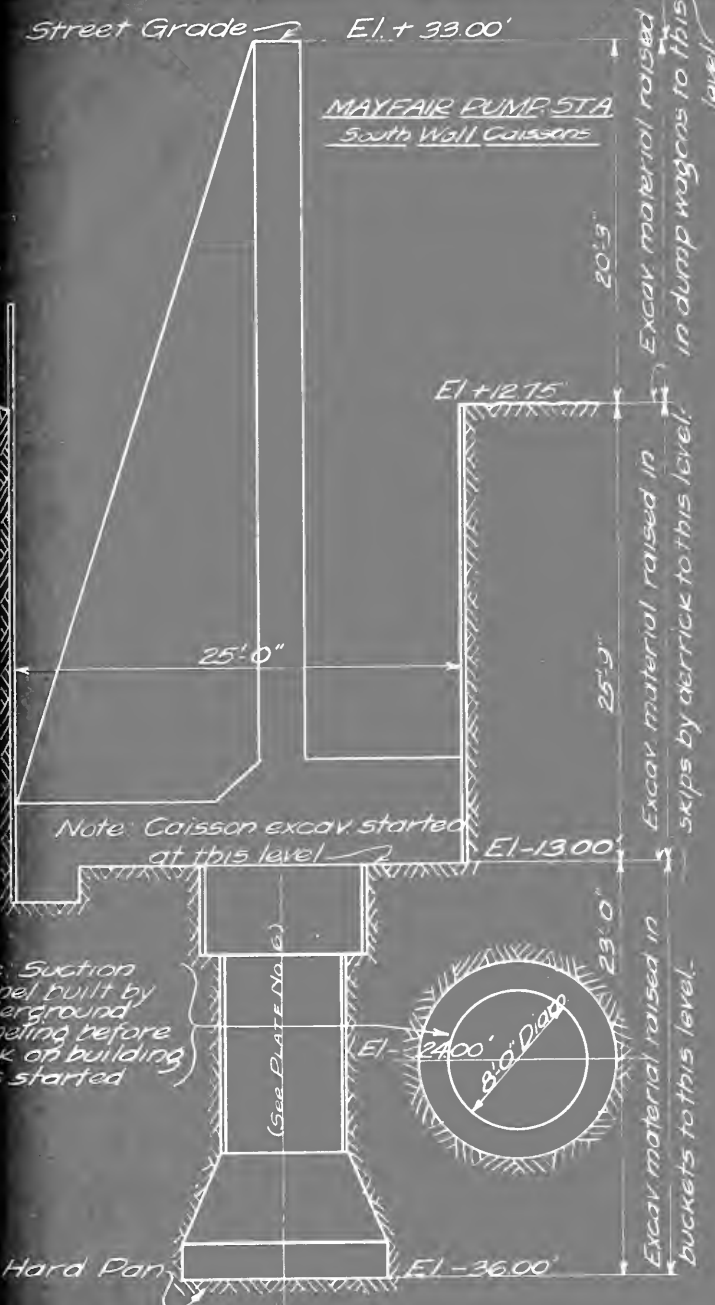
South Wall Shown.  
Similar Bracing Used  
in North, East and West  
Walls of Pump Room

MAYFAIR PUMPING STATION  
TYPICAL TRENCH BRACING.



Street Grade  $\rightarrow$  El. + 33.00'

MAYFAIR PUMP STA  
South Wall Caissons

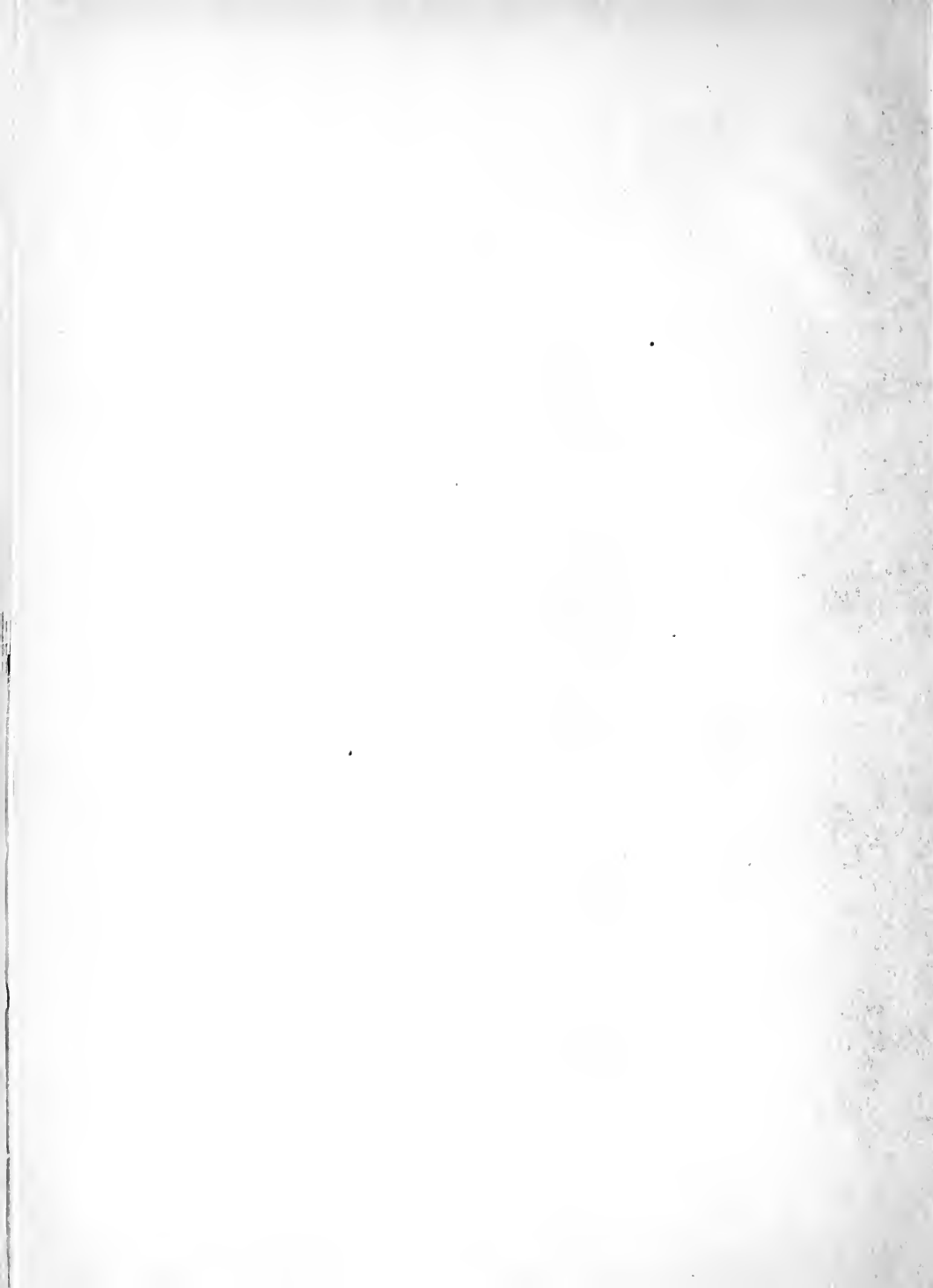


Section "A-A"  
Scale 1/8" = 1'-0"

PLATE NO. 5  
25'-0"  
13'-6" 26'-9"



SUCTION TUNNEL  
PLAN OF SOUTH WALL OF PUMP ROOM

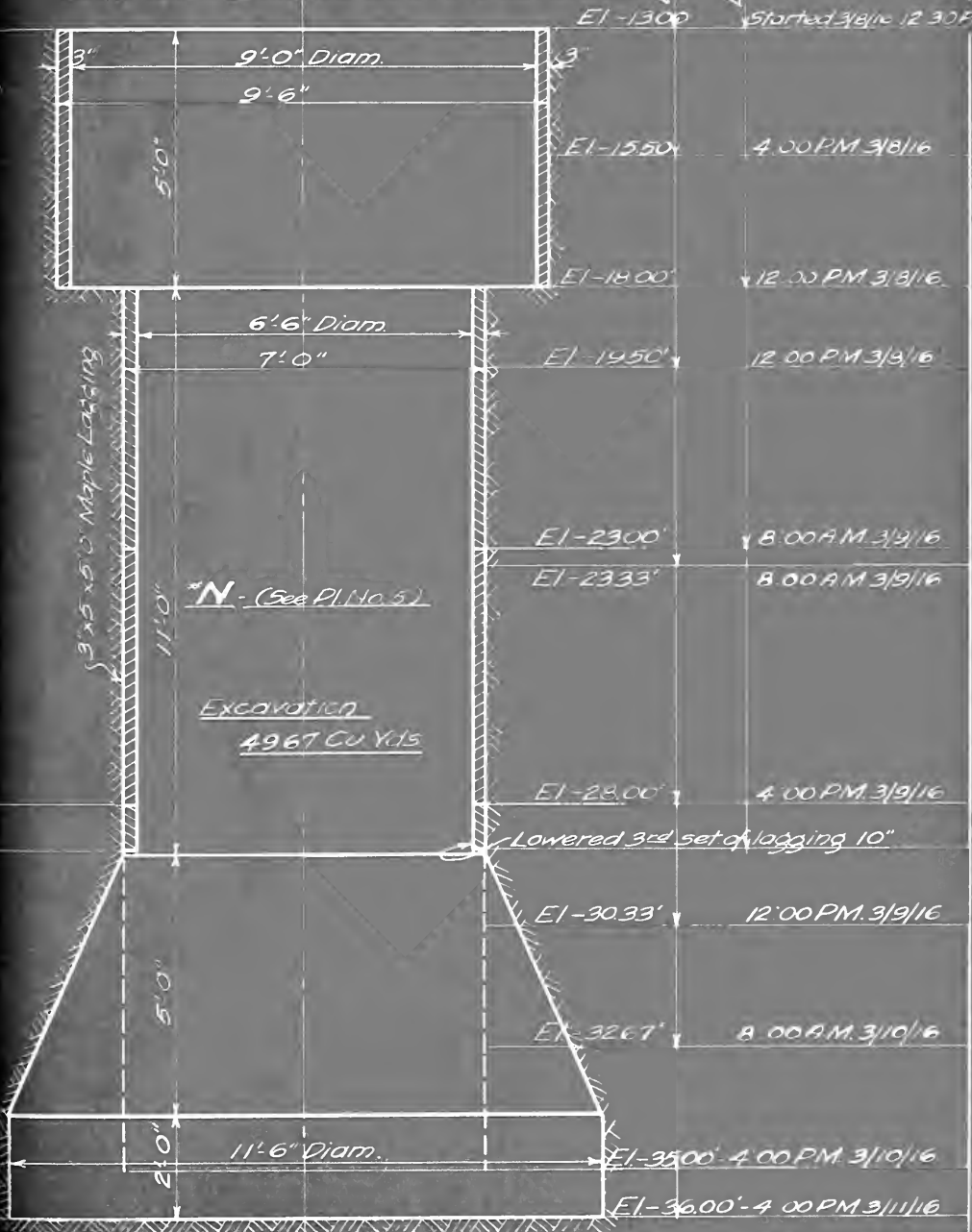




MAYFAIR PUMPING STATION  
Progress Diagram for Caisson Excavation

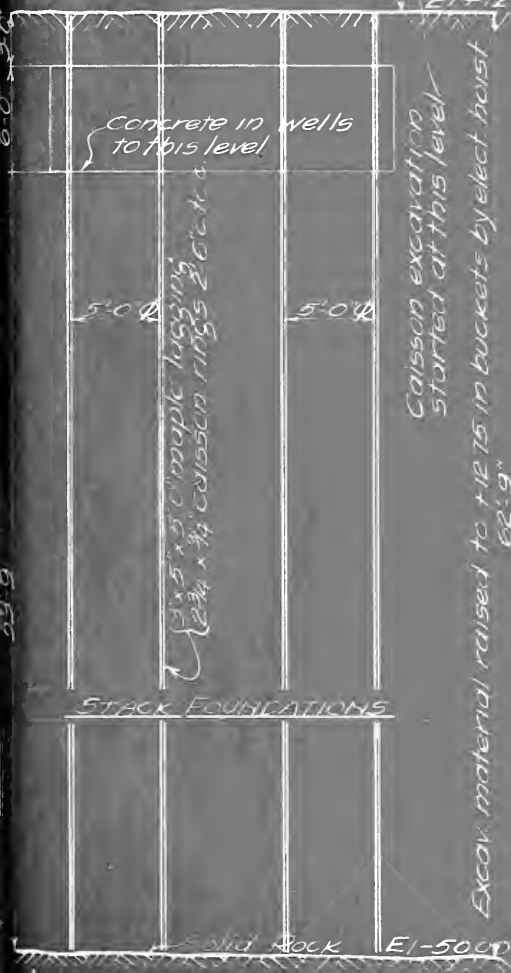
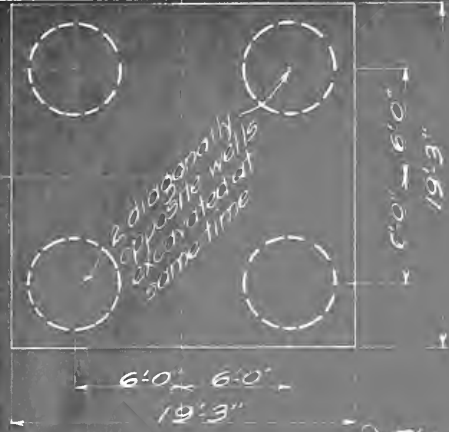
Excavating

Lagging





MAYFAIR PUMP STATION  
SOIL BORINGS NEAR STACK CAISSONS



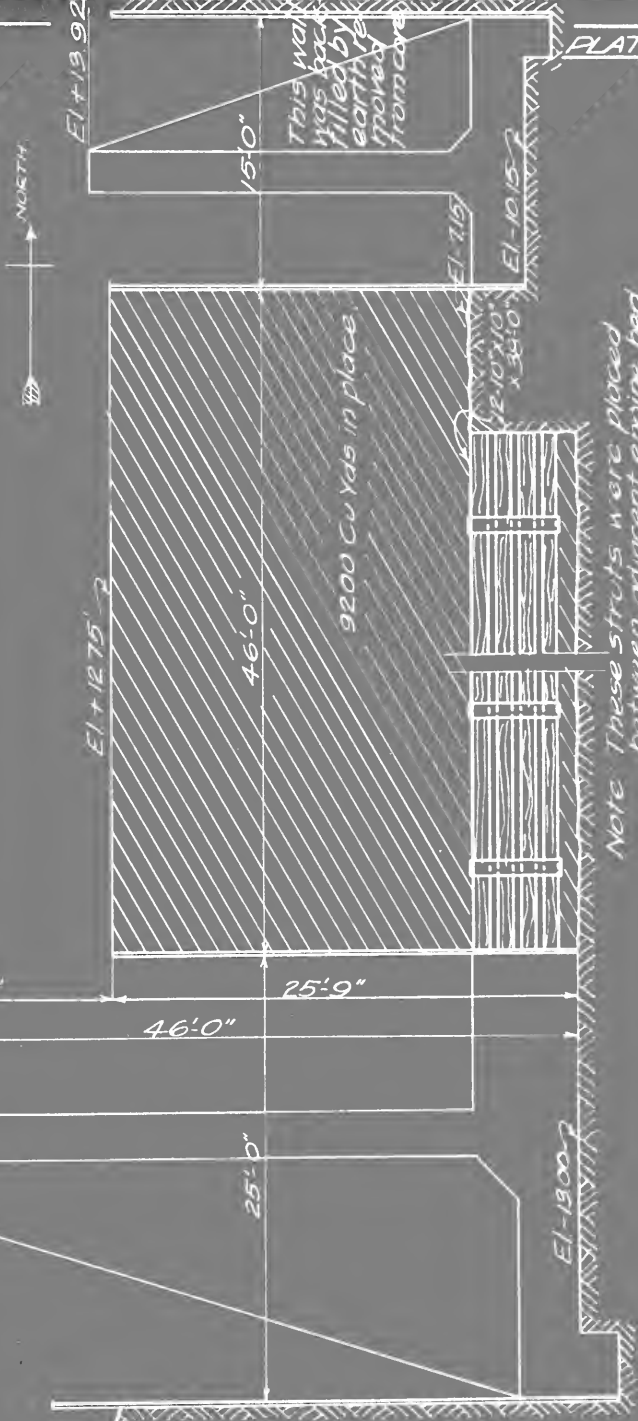
Excav material raised to +12.75 in buckets by elect hoist  
62'9"



Derrick set at El + 330  
this level.

This wall was backfilled by earth removed from core

Note Core represented by shaded area 9200 cu yds was removed by steam shovel and loaded into dump cars. Loaded cars were elevated to surface by derrick and emptied behind walls as backfill.

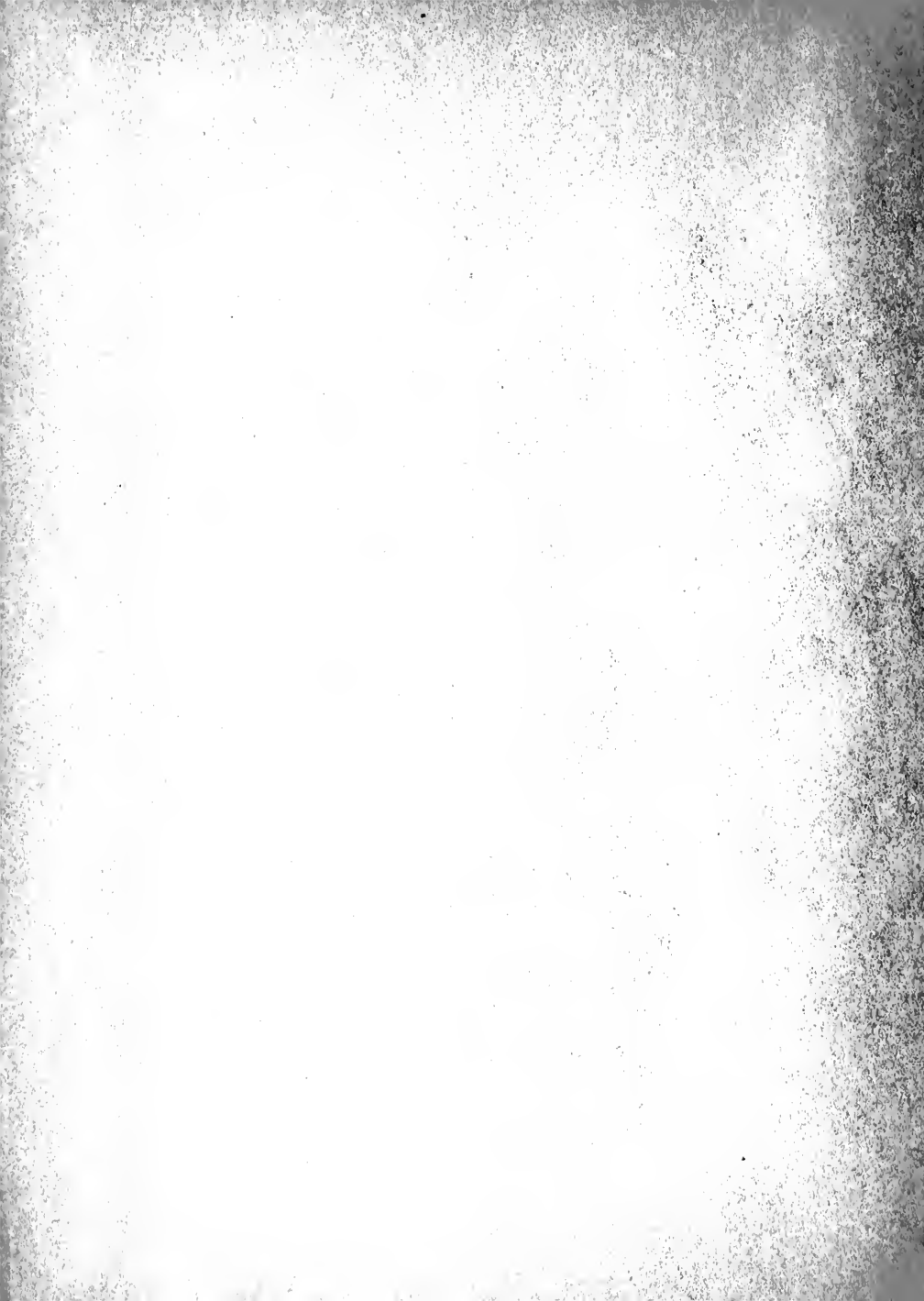


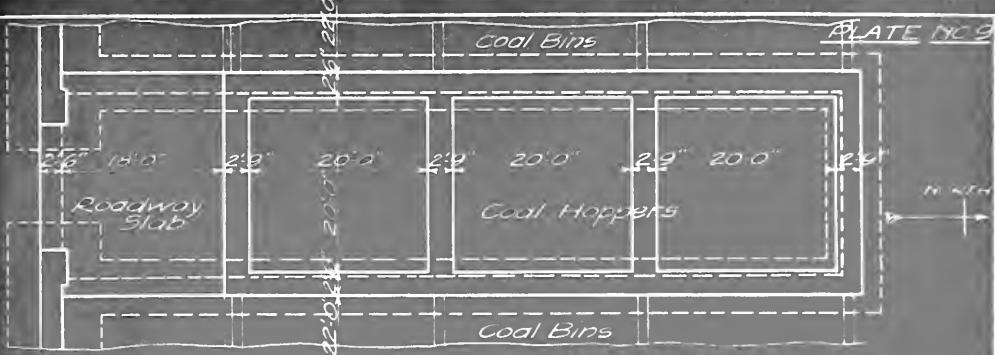
This wall was backfilled by earth removed from core

Note These struts were placed between adjacent engine bed locations, 31'-0" c/c

PLATE NO. 8

TRANSVERSE SECTION OF PUMP ROOM  
MAYFAIR PUMPING STATION

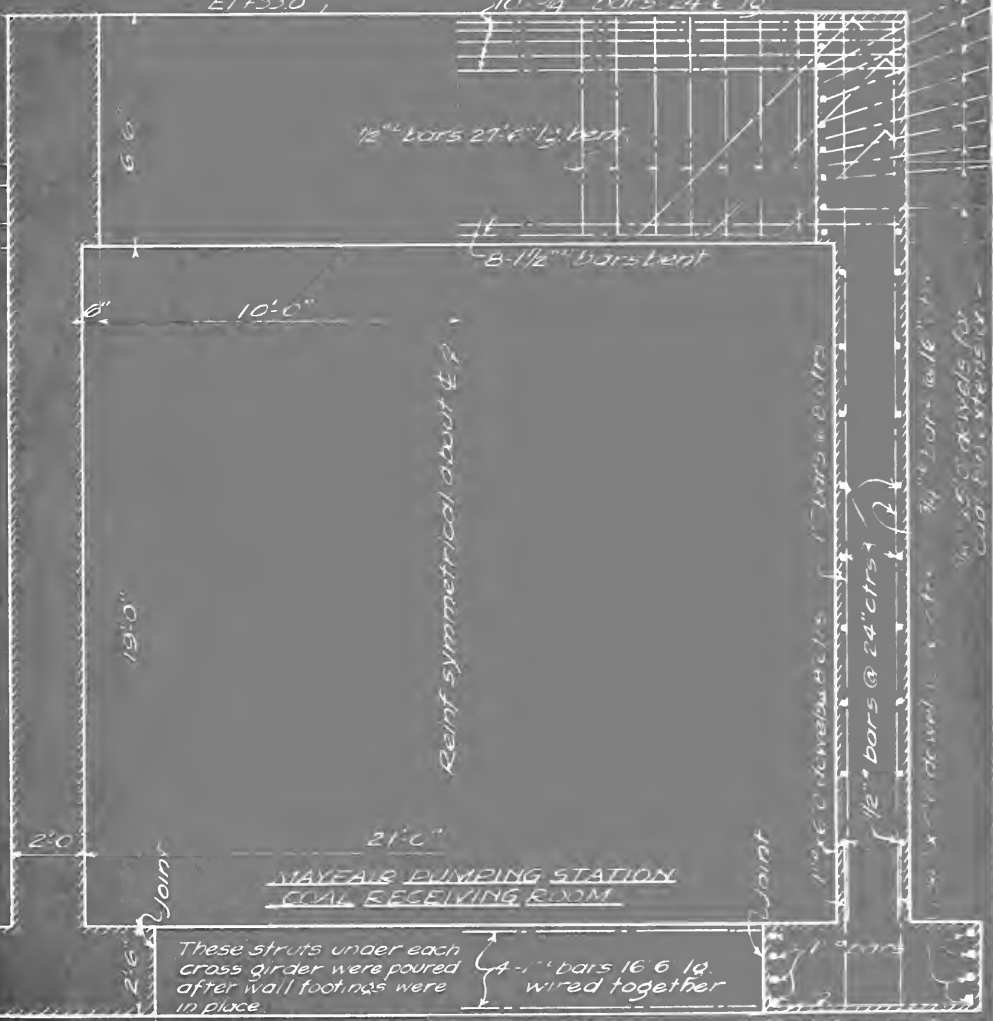




GENERAL PLAN

E1+330, 10-3/4" bars 24' C' 10

Tie bars left for extensolop  
Coal bins 10 size poured later



MAYFAIR PUMPING STATION  
COAL RECEIVING ROOM

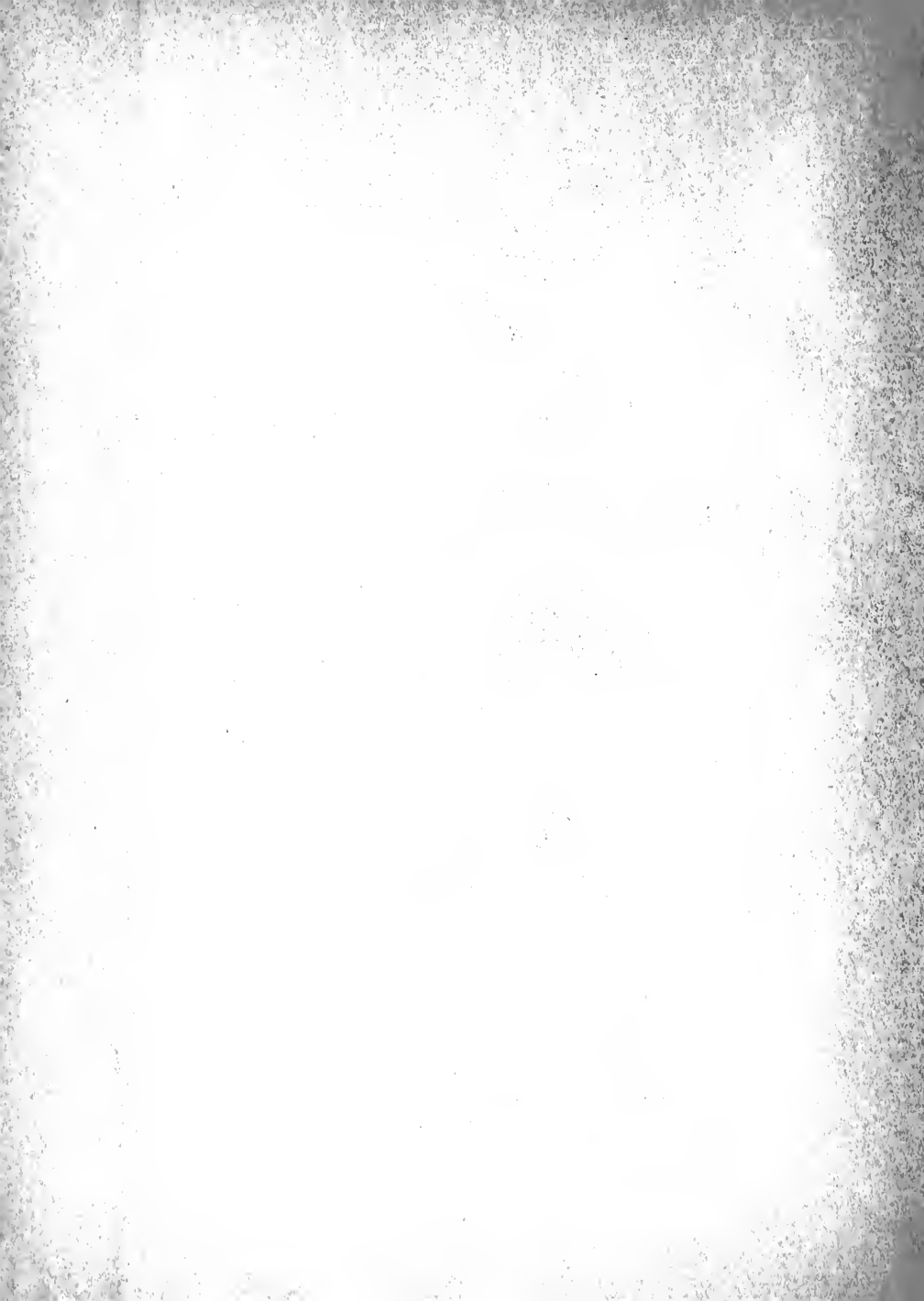
These struts under each cross girder were poured after wall footings were in place

CROSS SECTION

12" bars 24' C' 10  
8-1/2" bars bent  
12" bars @ 24" ctrs  
12" bars @ 24" ctrs  
12" bars @ 24" ctrs

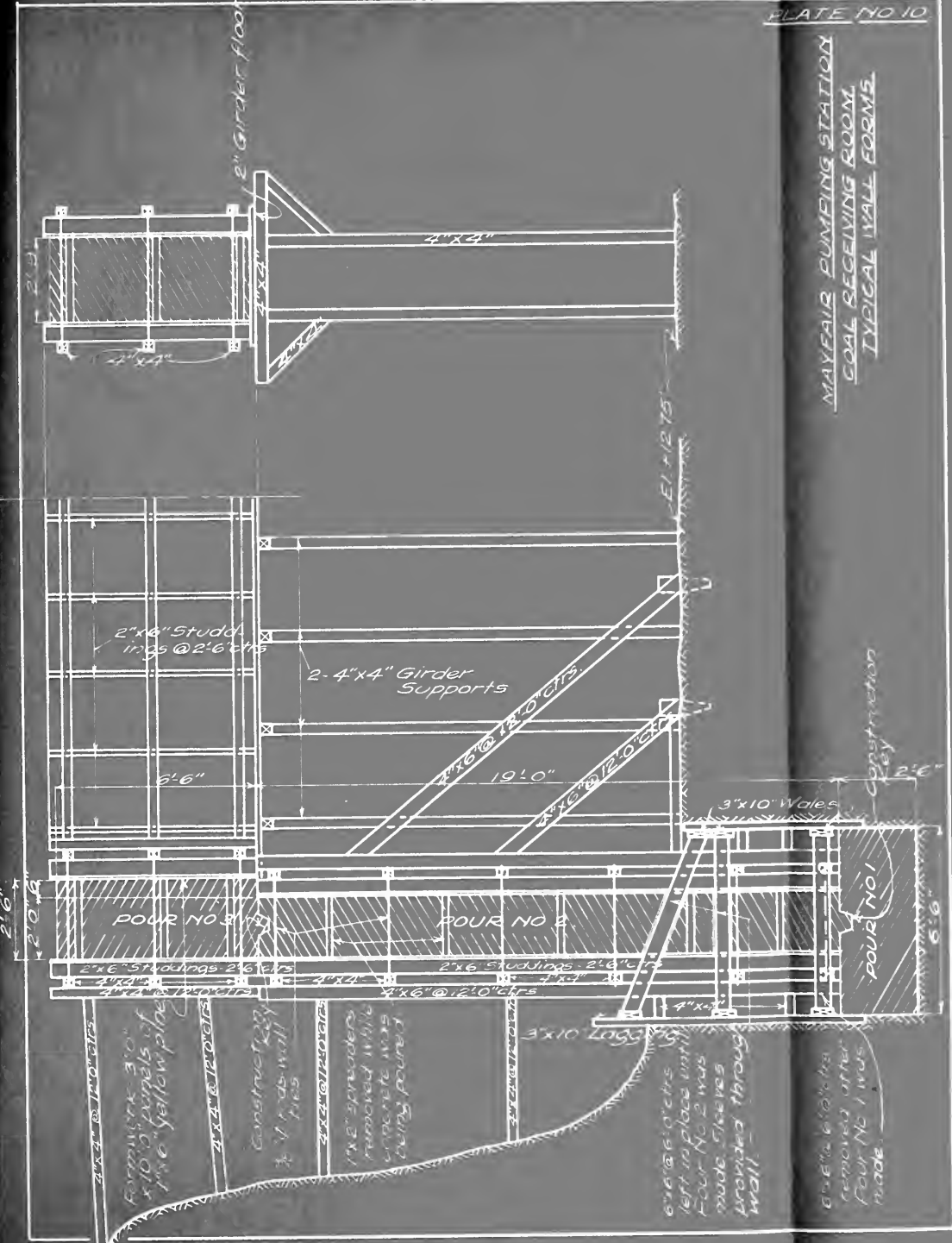
Joint

12" bars @ 24" ctrs





MAYFAIR PUMPING STATION  
COAL RECEIVING ROOM  
TYPICAL WALL FORMS



Remove 310  
x 10'0 panels of  
the yellow plate

Constructing  
3'4" ds wall  
ties

1"x2" spacers  
removed while  
concrete was  
being poured

6"x6" @ 6'0" c/c's  
left in place until  
Pour No 2 was  
made. Walers  
removed through  
wall.

6"x6" @ 6'0" c/c's  
removed after  
Pour No 1 was  
made.



WAYFAIR UNLOADING STATION

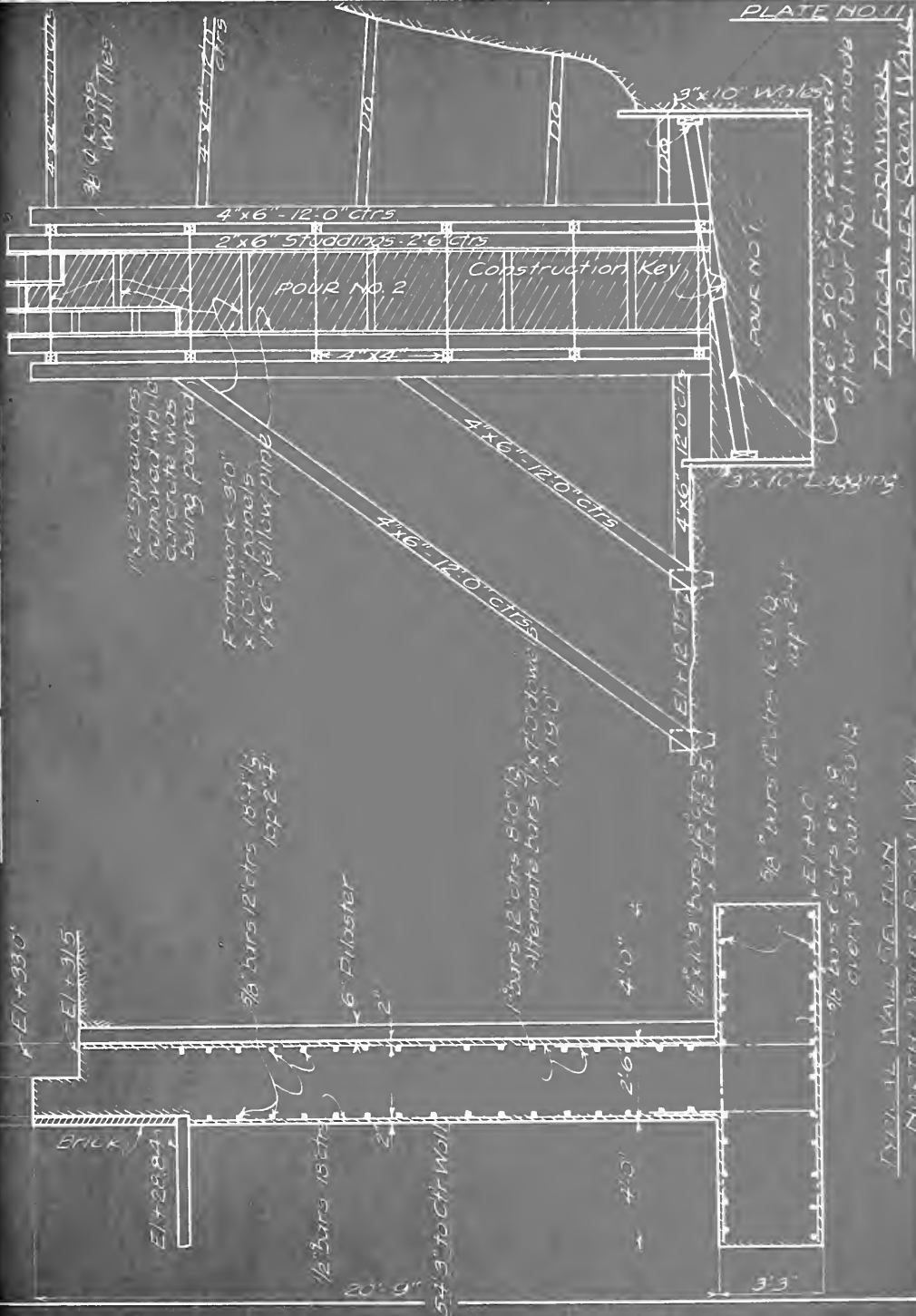


PLATE NO. 11

TYPICAL FORMWORK FOR ROOF ROOM WALL

6' x 6' 5' 0" CTS removed after Pour No. 1 was made

3' 0" Rods Wall Ties

CTS

4' x 6" - 12' 0" CTS

2' x 6" Studding - 2' 6" CTS

POUR NO. 2

Construction Key

4' x 6" - 12' 0" CTS

4' x 6" - 12' 0" CTS

CTS

3' x 10" Lagging

1/2" sprayers removed while concrete was being poured

Formwork 3' 0" x 10' 0" panels 1/2" x 6" yellow pine

3/8" bars 12" cts 18" x 15" 10p 2' 7"

6" Plaster

1/2" bars 12" cts 8' 0" lg alternate bars 1' x 7' 0" 1' x 19' 0"

3/8" bars 12" cts 10' 3" lg 10p 2' 7"

3/8" bars cts 8' 0" 10p 2' 7" every 3' 0" w/ 1' 0" lg

E/1+330' E/1+315'

BRICK E/1+288'

E/1+135' E/1+133'

E/1+90' E/1+90'

TYPICAL FORMWORK FOR ROOF ROOM WALL

1/2" bars 18" cts 20' 9" 5' 4" 9" to cft wall

4' 0" 4' 0" 2' 6"

3' 3"



PROGRAM.

Original trench shoring represented by dotted lines - Nos 1 to 9 inclusive.

Pour No 1 consists of 4" bed for steel rebar.

Pour No 2. Braces 10 & 11 removed.

Pour No 3. Brace No 9 removed.

Pour No 4. Braces Nos 4, 5, 6, 7 & 8 removed. Reshoring "A, B, C, D, & E" placed. Also "M & N" placed.

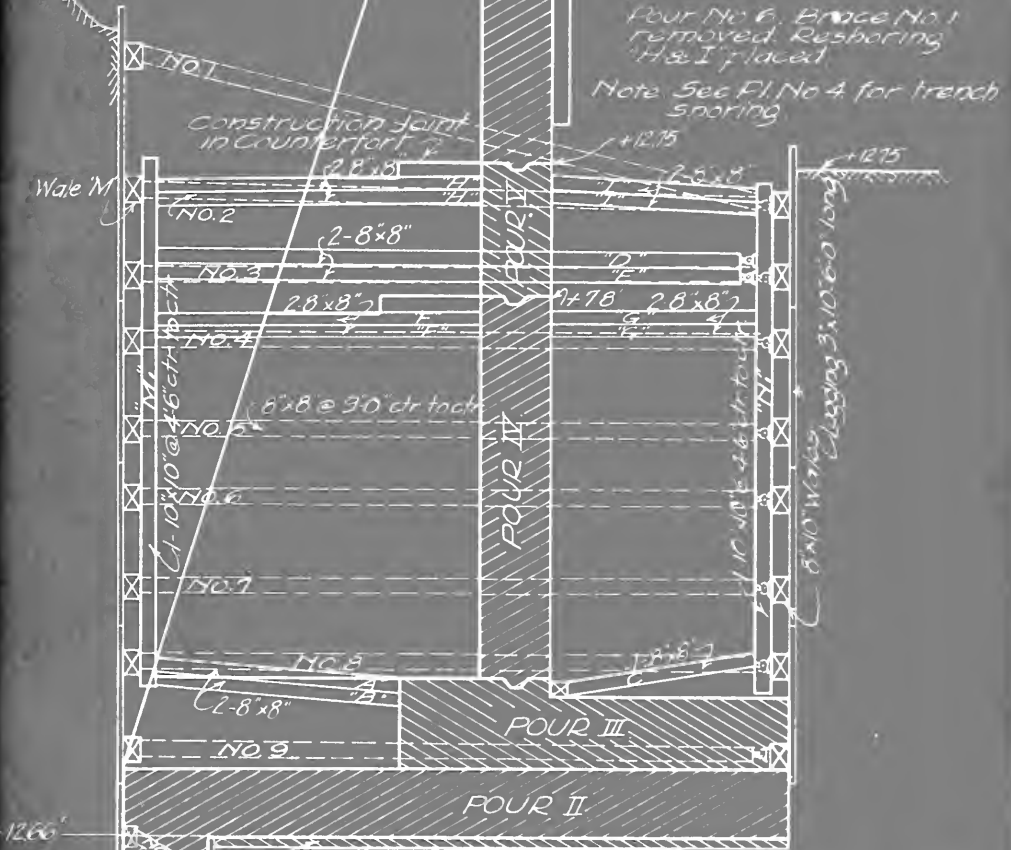
Pour No 5. Braces Nos 2 & 3 removed; also shores "D & E". Reshoring "F & G" placed.

Pour No 6. Brace No 1 removed. Reshoring "H & I" placed.

Note. See Fig. No 4 for trench shoring.

Wale "M"  
1st Step of bracing shown thus

Wale "M"  
2nd Step of bracing shown thus

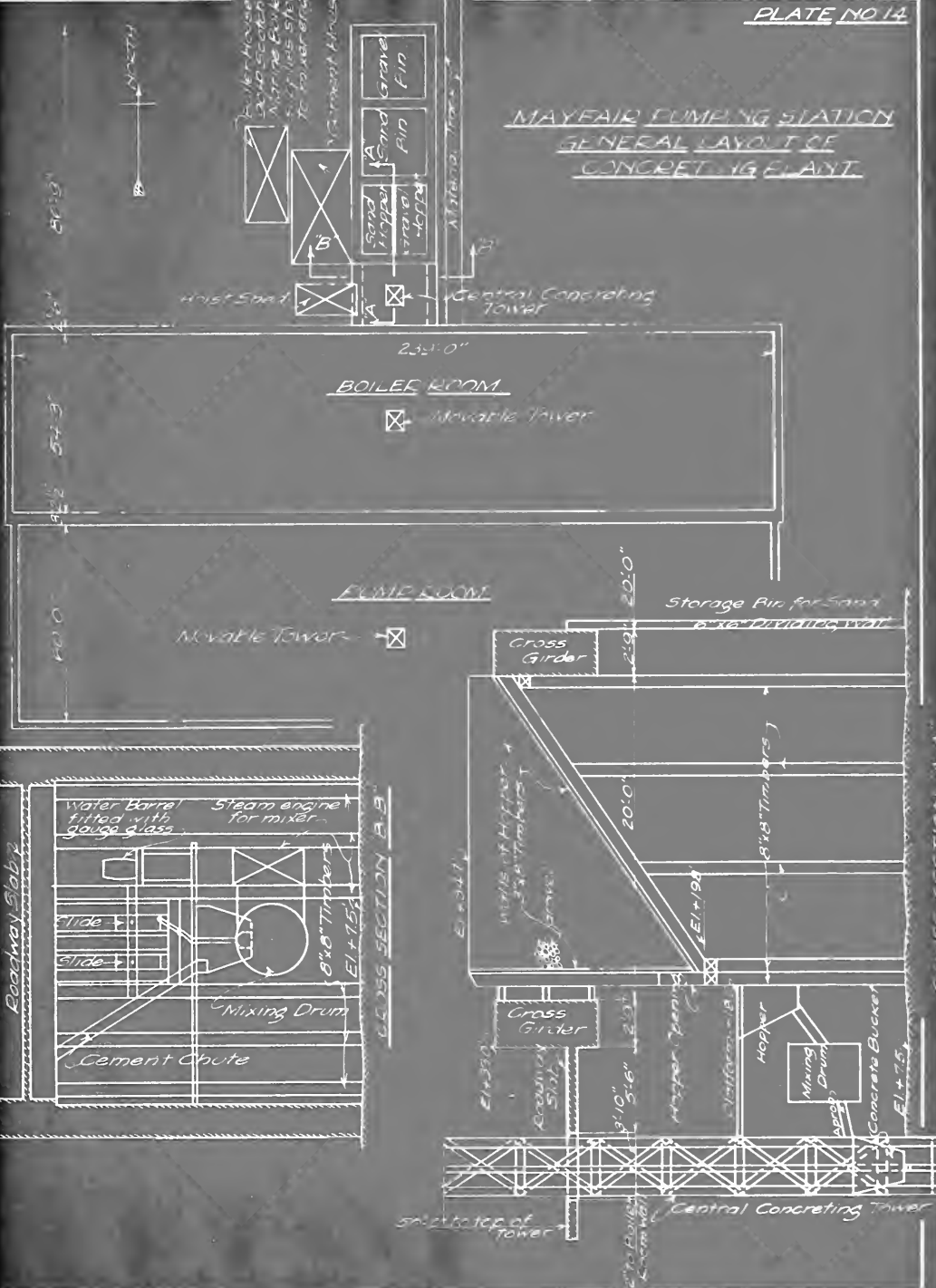


-1266'  
-1466'  
-1500'

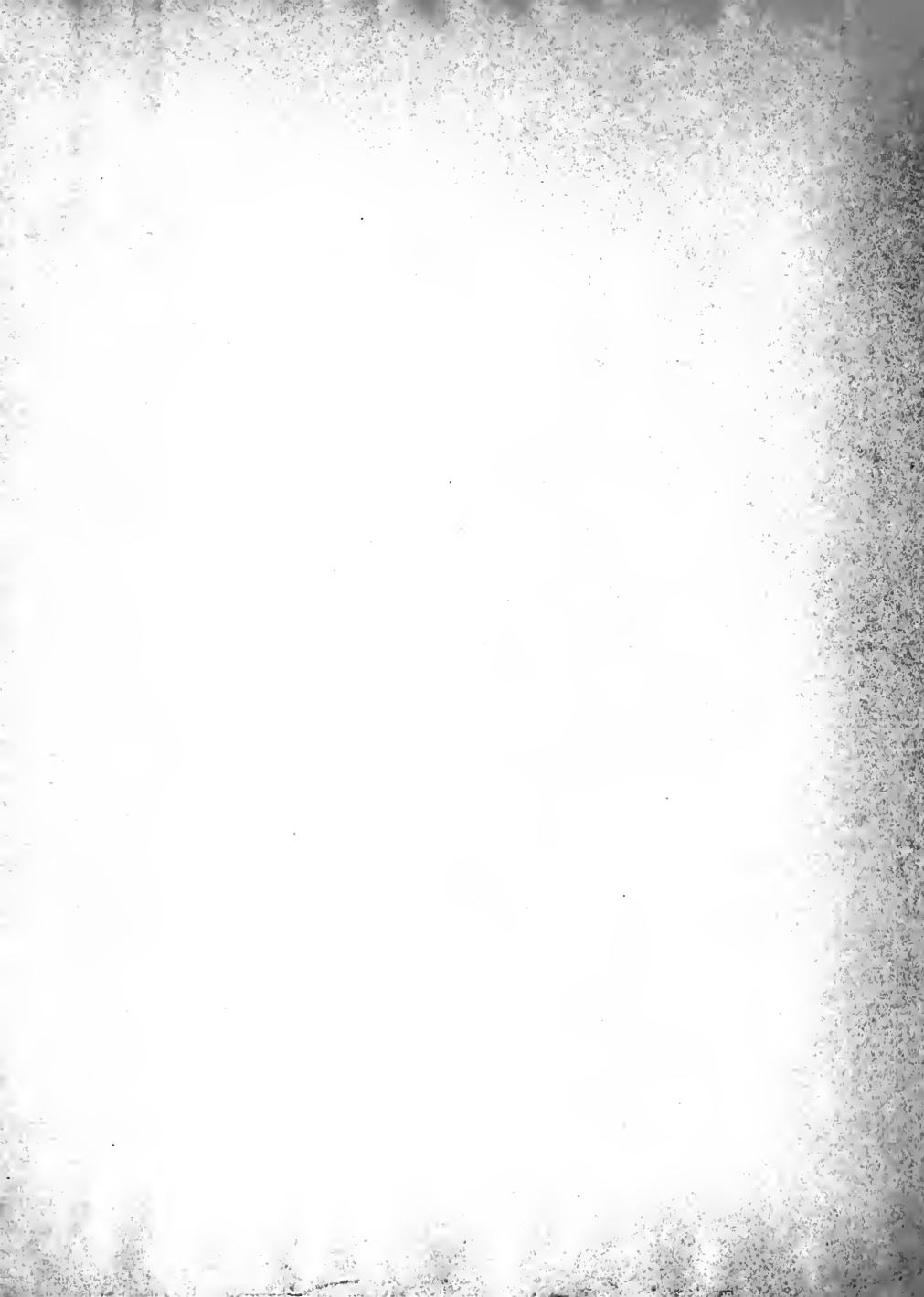
MAYEAK PUMPING STATION  
METHOD OF CONCRETING  
PUMP ROOM WALLS



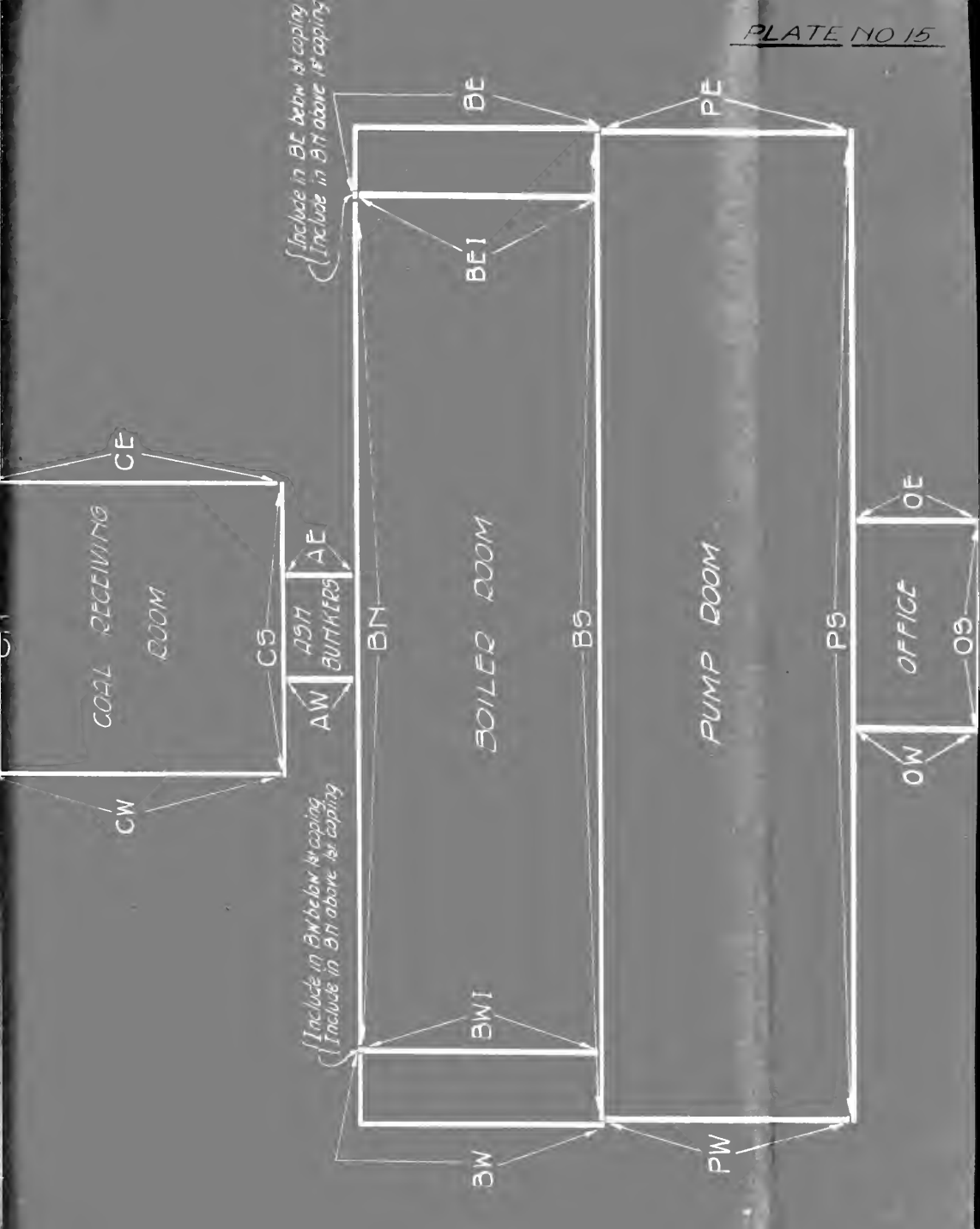
MAYFAIR PUMPING STATION  
GENERAL LAYOUT OF  
CONCRETING PLANT.



CROSS SECTION A-A









PLACE WHERE WORK WAS DONE

SEWERS

PIPS 2

HIGHWAYS  
AND  
RAILWAYS 3

BILDS 4

BRIDGES 5

TUNNELS 6

MACHINERY 7

BOARDS 8

PIPING 9

CLASS OF WORK

CONCRETE

MASONRY

EXCAVATION

CARPENTER WORK OTHER THAN FORMS

WORK DONE

NOT DEVELOPED ON THIS SHEET

NOT DEVELOPED ON THIS SHEET

FOUND 1

DIGGING 2

HOISTING 3

PUMPING 4

CLEARING SITE 5

BACKFILLING 6

BRACING 7

GRADING 8

TRANSFERRING 9

HAIR 1

TEST 2

STEAM SHOVEL 3

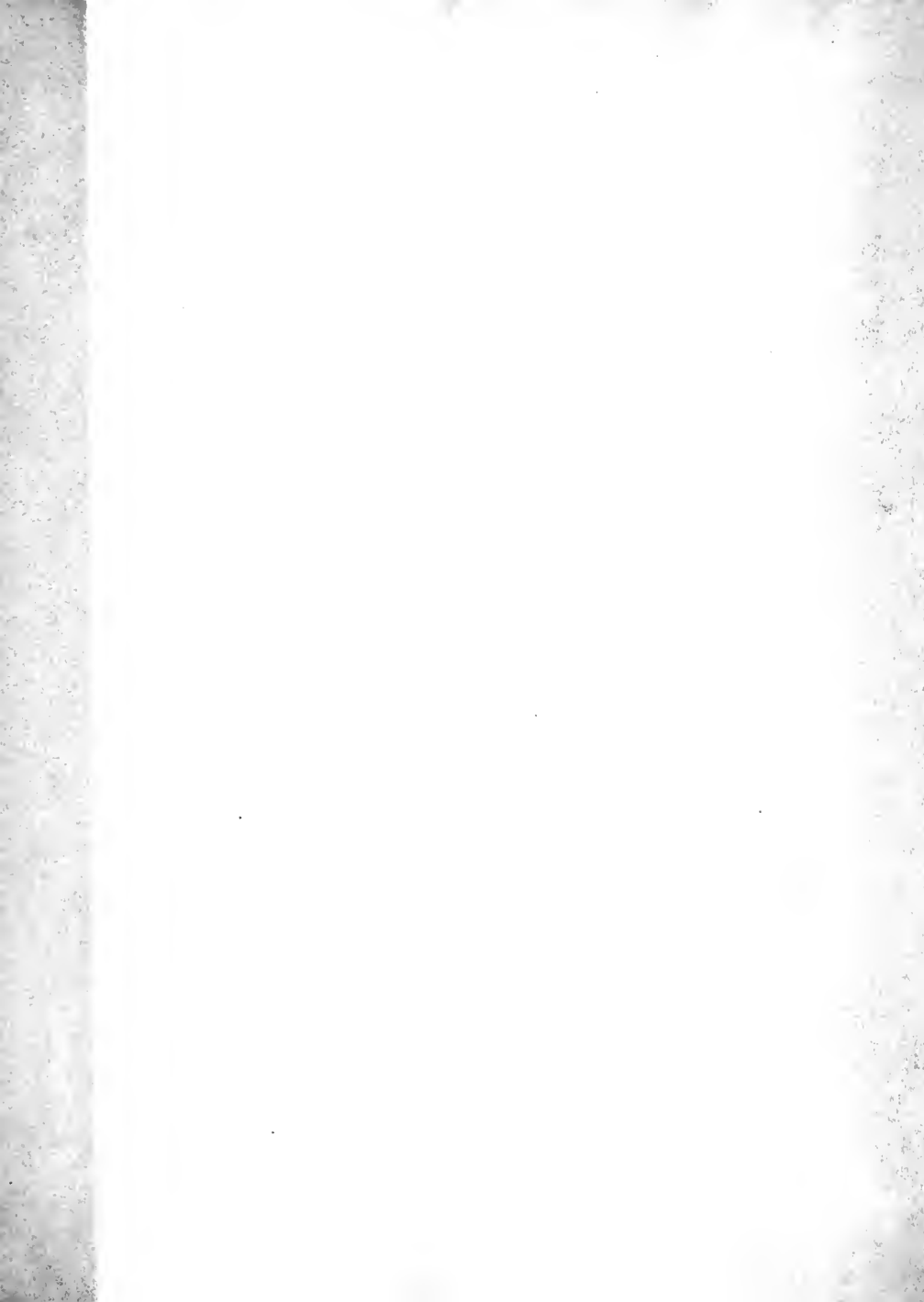
HOIST 4

DEDICK 5

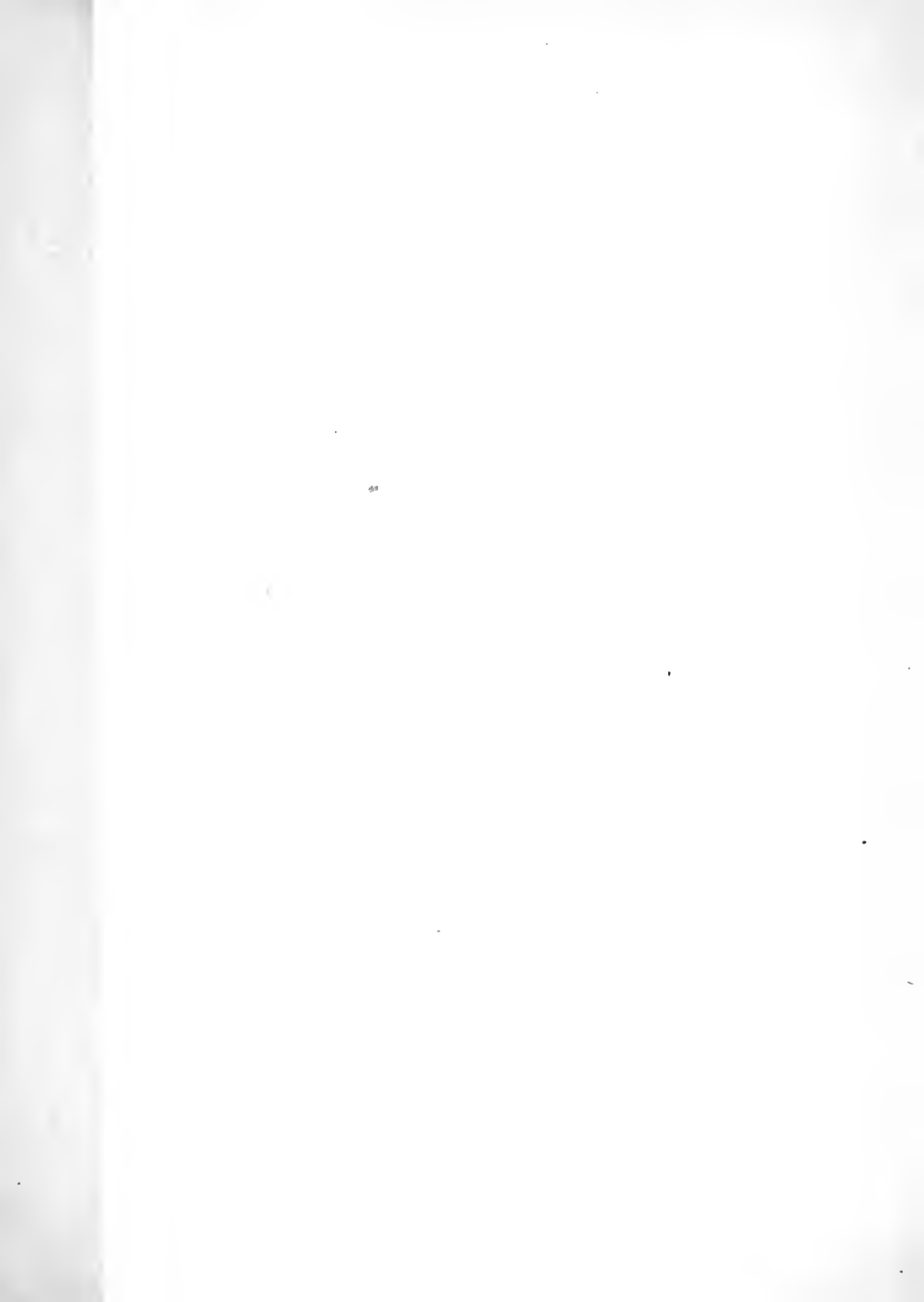
CORNER 6

NOT DEVELOPED ON THIS SHEET

NOTE: Refer to standard sheet for correct insertions.







INDEX OF PHOTOGRAPHS.

- Photo No. 1. General View of Work in Preliminary Stages.
- Photo No. 2. North Boiler Room Wall.
- Photo No. 3. Open Cut Excavation by Steam Shovel.
- Photo No. 4. Trench Bracing for Pump Room Walls.
- Photo No. 5. General View of South and West Engine Room Walls.
- Photo No. 6. Coal Receiving Room.
- Photo No. 7. Boiler Room.
- Photo No. 8. Pump Room.



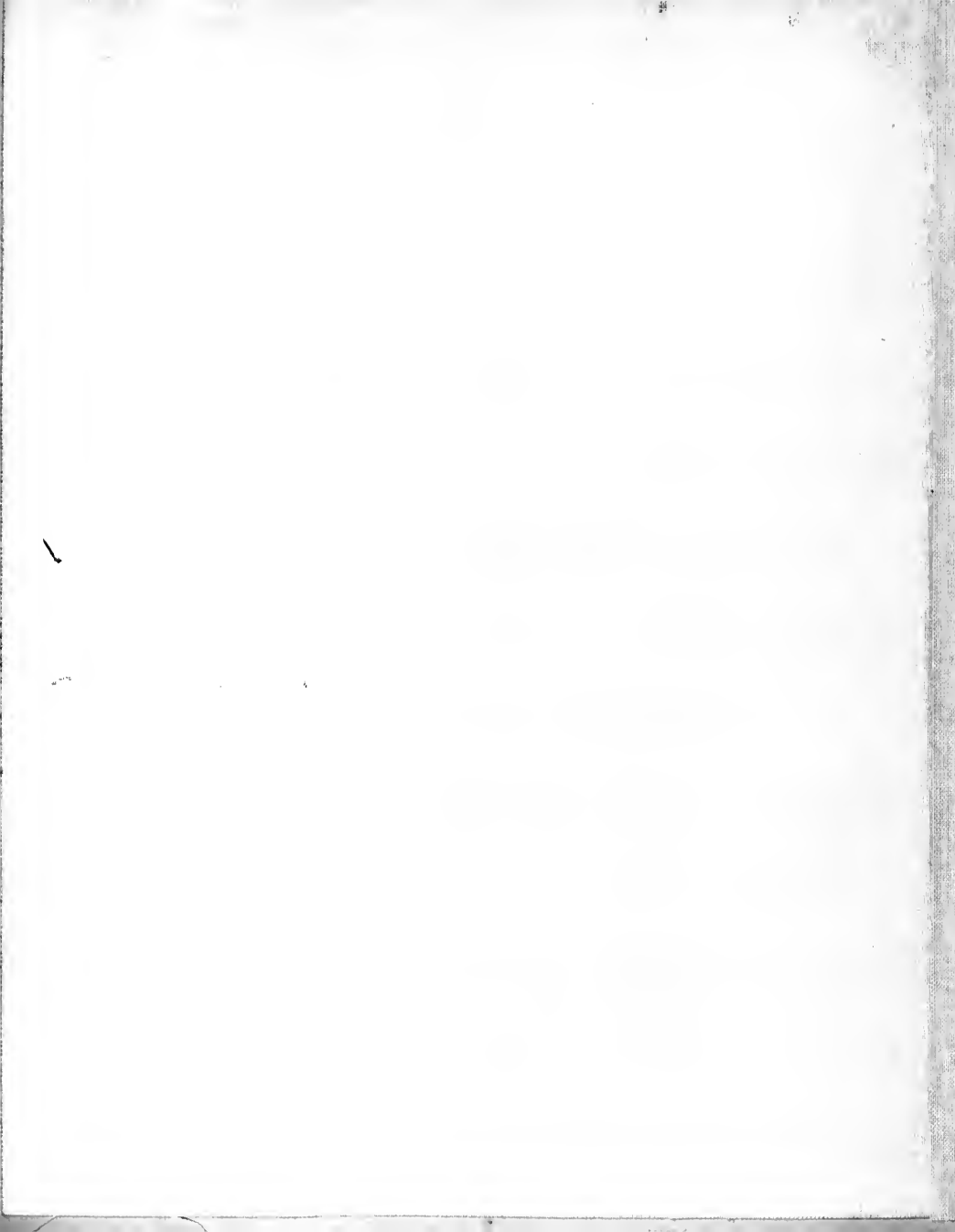


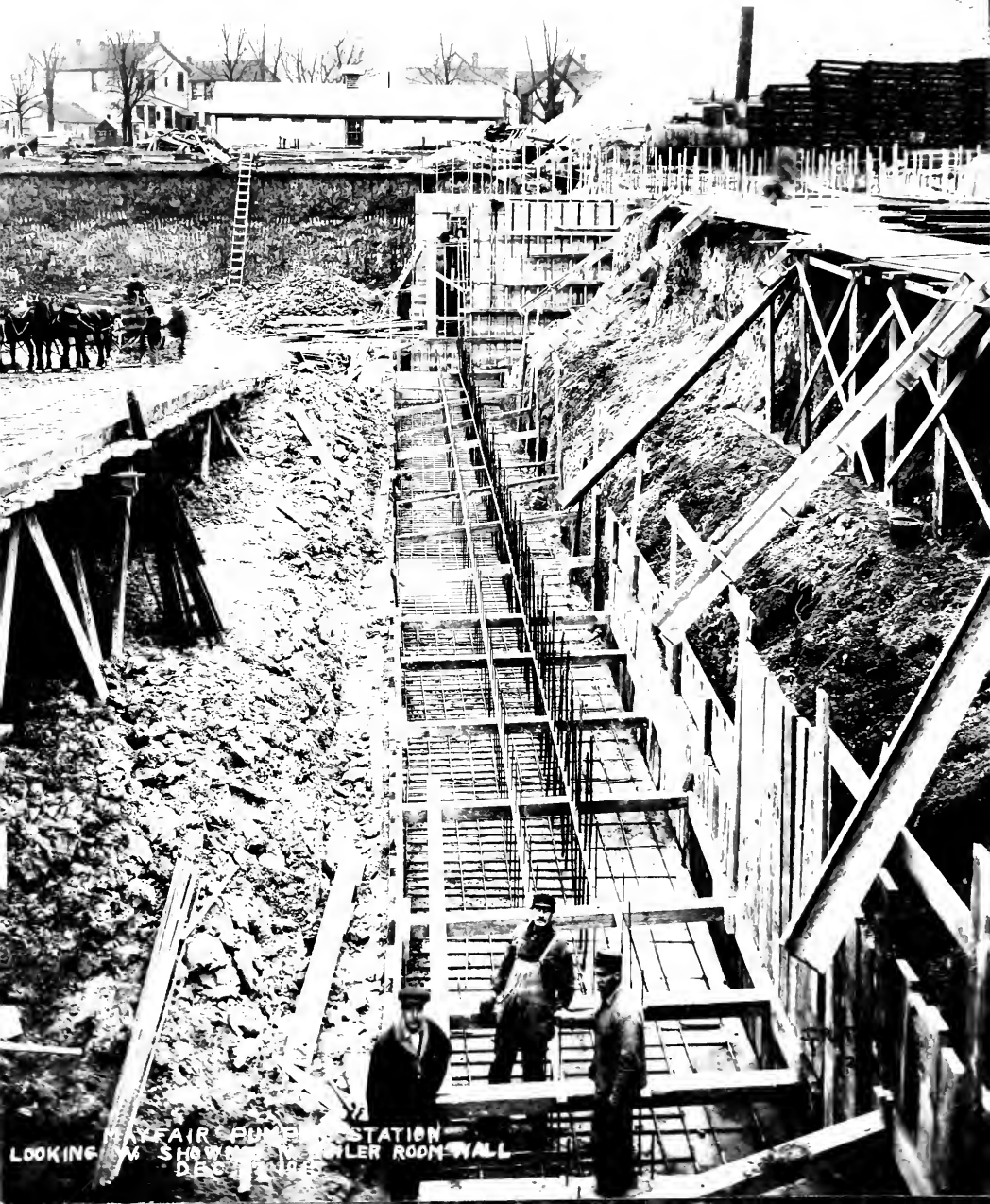
PHOTO NO. 1.

Rock pile

J. R. TAYLOR  
113







REPAIR TUNNEL STATION  
LOOKING W. SHOWING BOILER ROOM WALL  
DEC. 1918

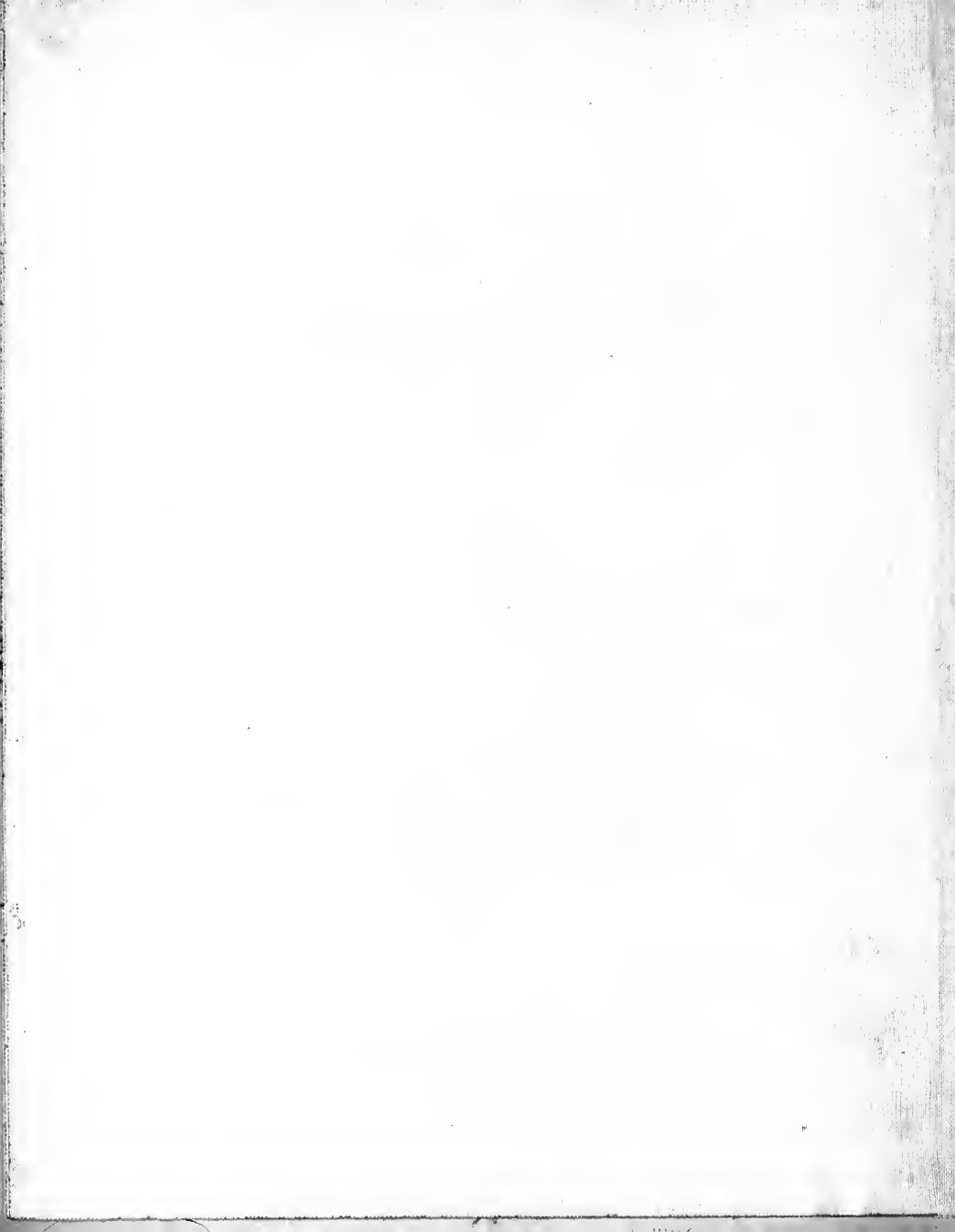
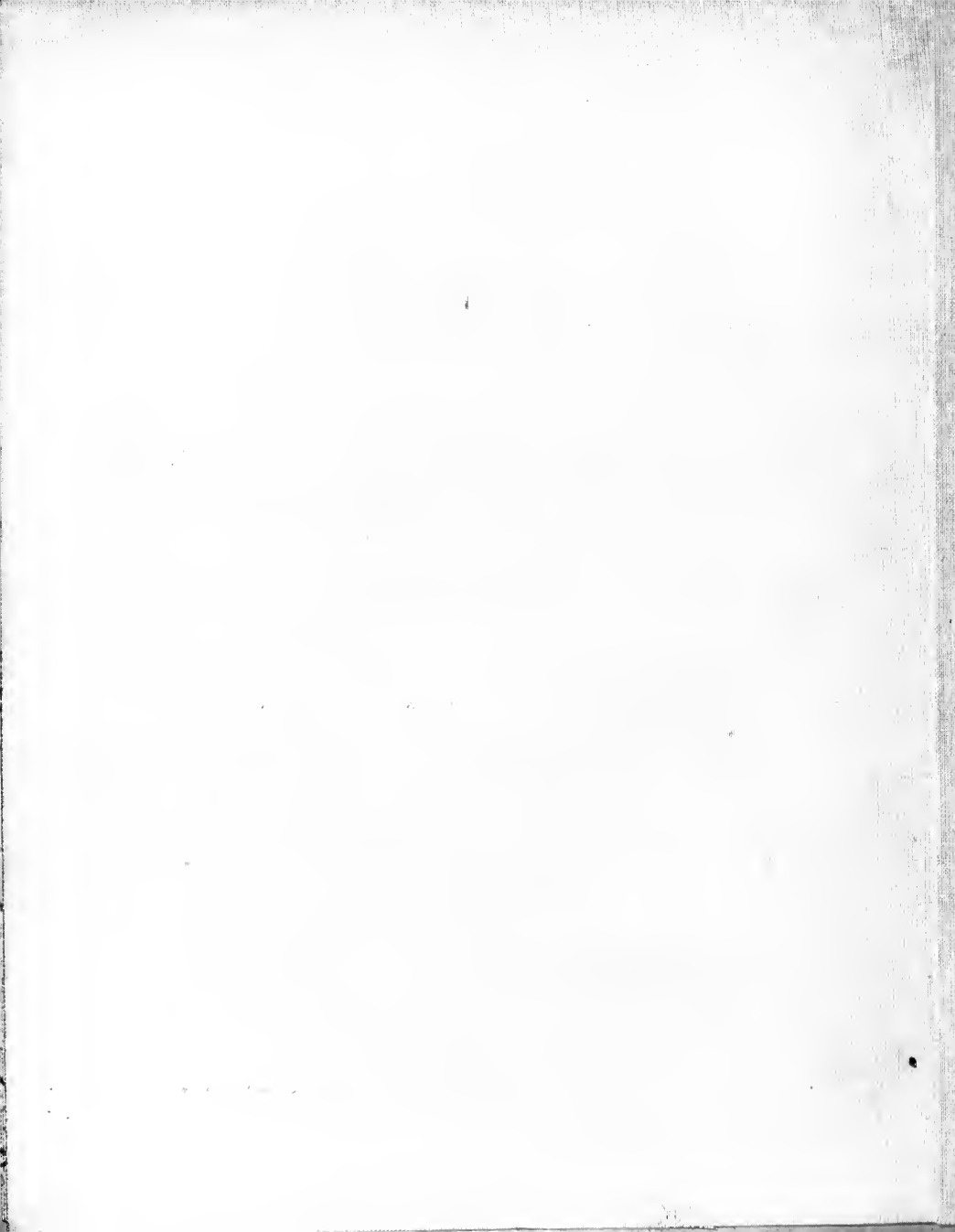


PHOTO N. 1. 3.



MAYFAIR PUMPING STATION  
LOOKING NW  
JAN 11 1945

TAYLOR  
137



MAYBANK PUMPING STATION  
LOOKING SE.  
FEB. 25 1916

U.S. GEOLOGICAL SURVEY  
18 000000

J. R. TAYLOR  
157

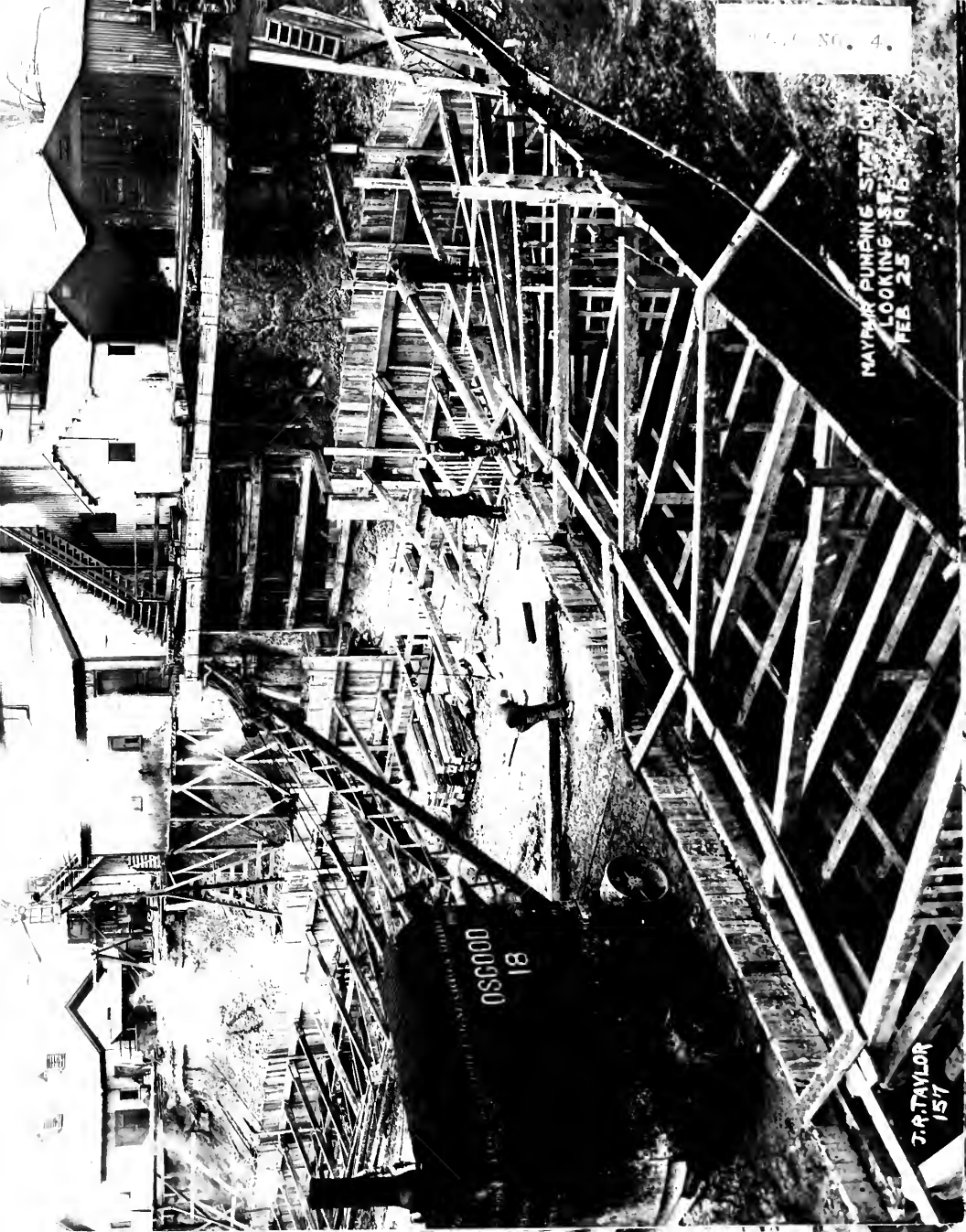






PHOTO NO. 5.

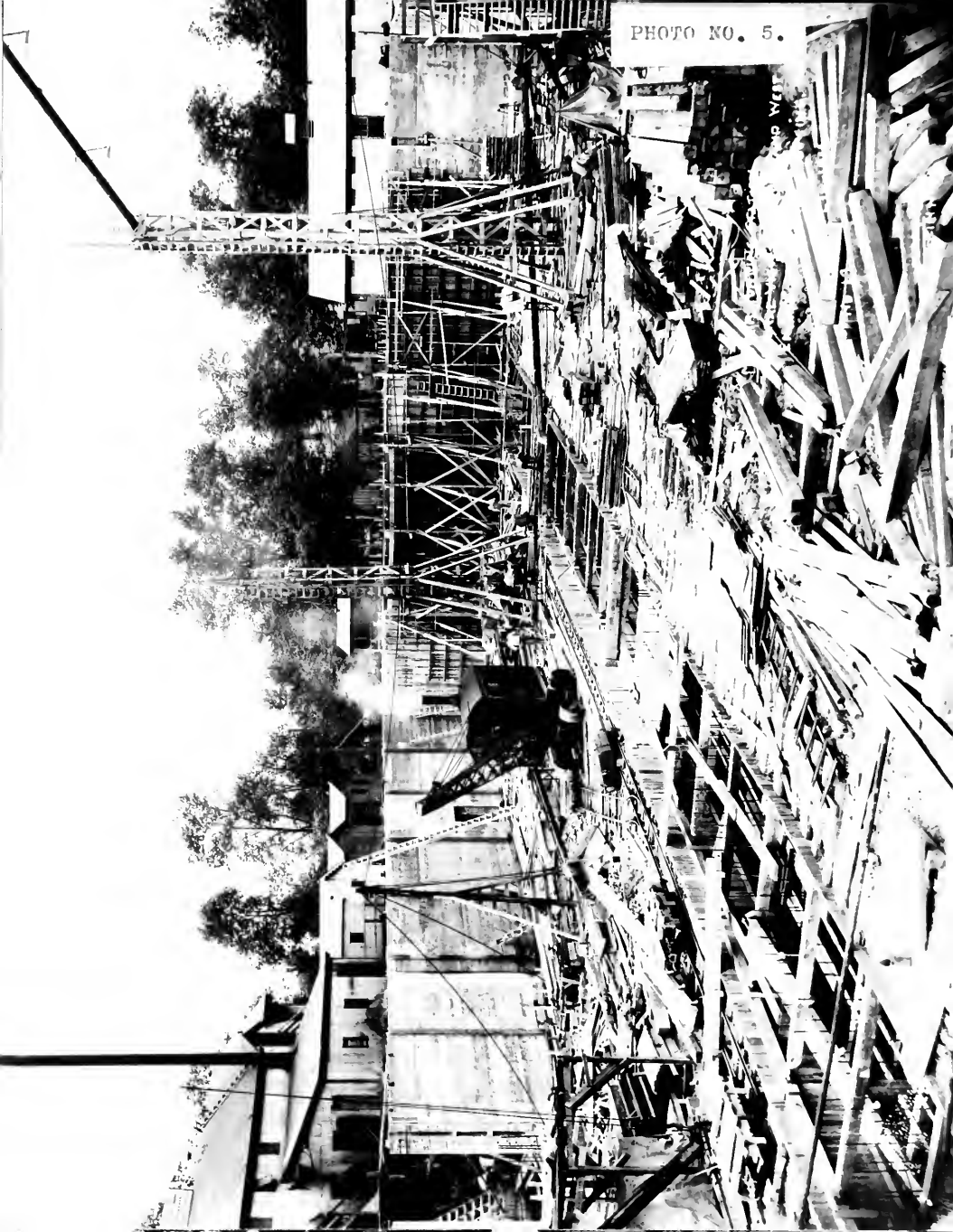






PLATE NO. 6.

MAYFAIR PUMPING STATION  
COAL RECEIVING ROOM LOOKING S  
JAN 11 1915

J.R. TAYLOR  
140



PHOTO NO. 7.

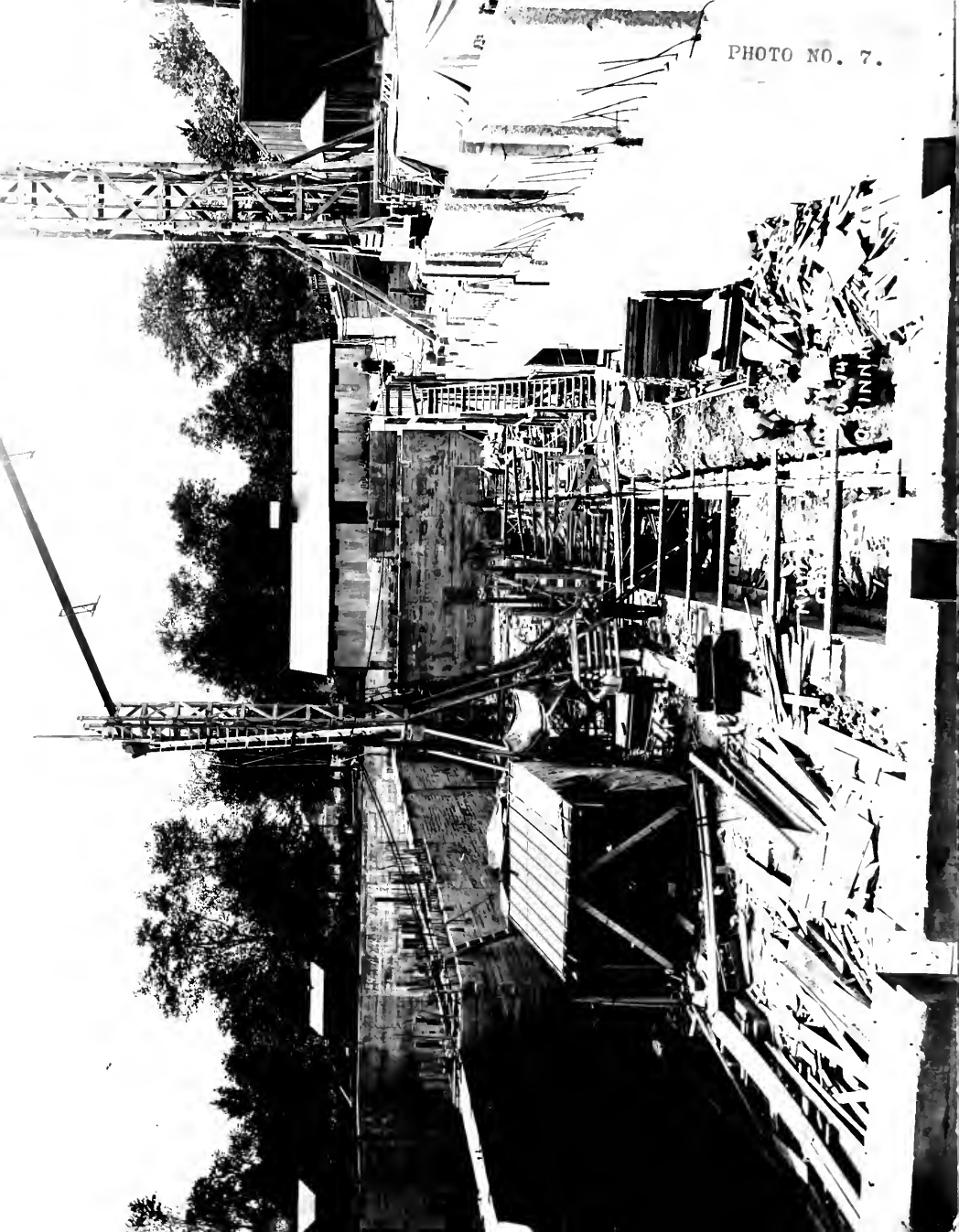
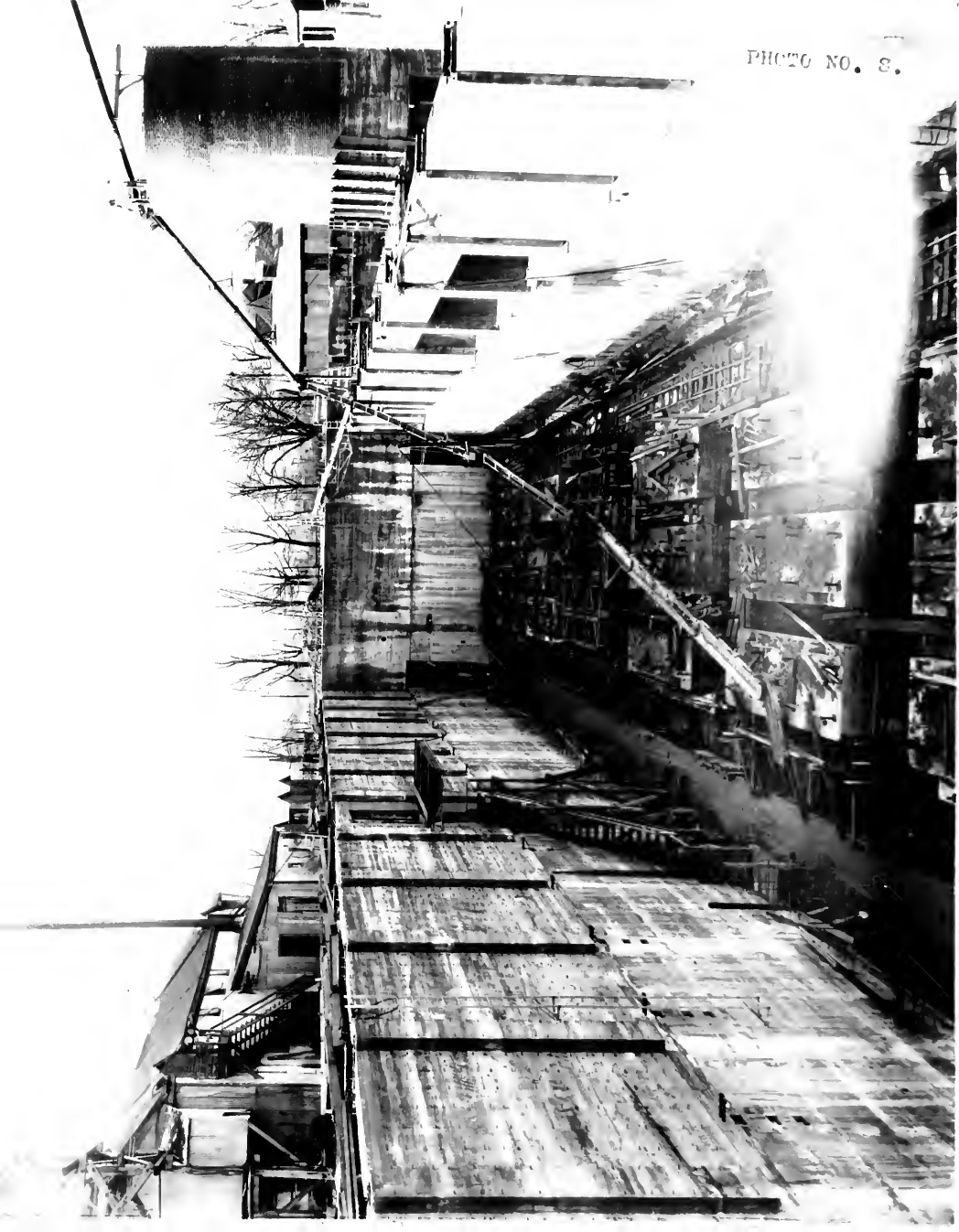




PHOTO NO. 8.



11-11-11  
2100 ALICE ST  
PHOENIX, ARIZONA 85006













