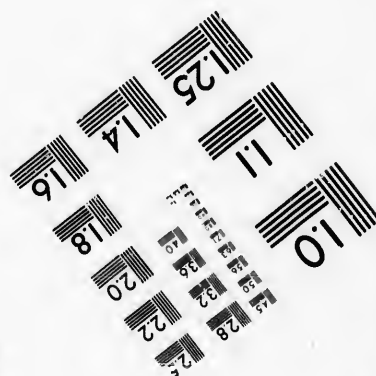
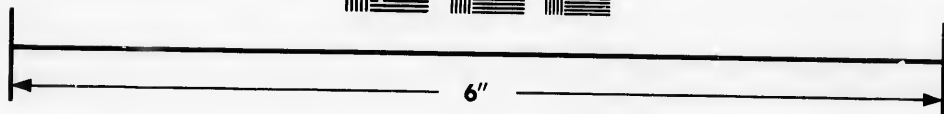
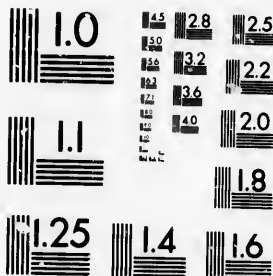


**IMAGE EVALUATION  
TEST TARGET (MT-3)**



**Photographic  
Sciences  
Corporation**

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

**CIHM/ICMH  
Microfiche  
Series.**

**CIHM/ICMH  
Collection de  
microfiches.**



**Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques**

**© 1986**

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.

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.

- |  |  |
|--|--|
| <input type="checkbox"/> Coloured covers/<br>Couverture de couleur   | <input type="checkbox"/> Coloured pages/<br>Pages de couleur   |
| <input type="checkbox"/> Covers damaged/<br>Couverture endommagée  | <input type="checkbox"/> Pages damaged/<br>Pages endommagées   |
| <input type="checkbox"/> Covers restored and/or laminated/<br>Couverture restaurée et/ou pelliculée  | <input type="checkbox"/> Pages restored and/or laminated/<br>Pages restaurés et/ou pelliculés  |
| <input type="checkbox"/> Cover title missing/<br>Le titre de couverture manque   | <input checked="" type="checkbox"/> Pages discoloured, stained or foxed/<br>Pages décolorées, tachetées ou piquées   |
| <input type="checkbox"/> Coloured maps/<br>Cartes géographiques en couleur   | <input type="checkbox"/> Pages detached/<br>Pages détachées  |
| <input type="checkbox"/> Coloured ink (i.e. other than blue or black)/<br>Encre de couleur (i.e. autre que bleue ou noire)   | <input checked="" type="checkbox"/> Showthrough/<br>Transparence   |
| <input type="checkbox"/> Coloured plates and/or illustrations/<br>Planches et/ou illustrations en couleur  | <input type="checkbox"/> Quality of print varies/<br>Qualité inégale de l'impression   |
| <input type="checkbox"/> Bound with other material/<br>Relié avec d'autres documents   | <input type="checkbox"/> Includes supplementary material/<br>Comprend du matériel supplémentaire   |
| <input type="checkbox"/> Tight binding may cause shadows or distortion<br>along interior margin/<br>La reliure serrée peut causer de l'ombre ou de la<br>distorsion le long de la marge intérieure   | <input type="checkbox"/> Only edition available/<br>Seule édition disponible   |
| <input type="checkbox"/> Blank leaves added during restoration may<br>appear within the text. Whenever possible, these<br>have been omitted from filming/<br>Il se peut que certaines pages blanches ajoutées<br>lors d'une restauration apparaissent dans le texte,<br>mais, lorsque cela était possible, ces pages n'ont<br>pas été filmées. | <input type="checkbox"/> Pages wholly or partially obscured by errata<br>slips, tissues, etc., have been refilmed to<br>ensure the best possible image/<br>Les pages totalement ou partiellement<br>obscurcies par un feuillet d'errata, une pelure,<br>etc., ont été filmées à nouveau de façon à<br>obtenir la meilleure image possible. |
| <input type="checkbox"/> Additional comments: /<br>Commentaires supplémentaires:   |  |

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

10X	14X	18X	22X	26X	30X
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
12X	16X	20X	24X	28X	32X

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

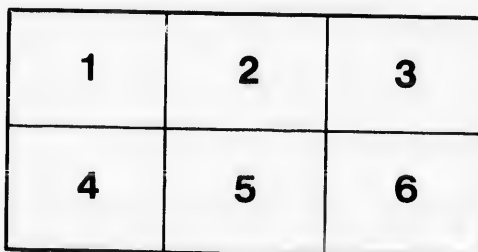
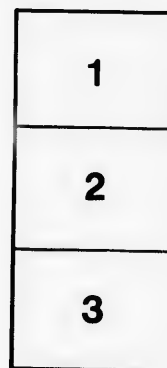
Library of the Public  
Archives of Canada

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  $\rightarrow$  (meaning "CONTINUED"), or the symbol  $\nabla$  (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:

La bibliothèque des Archives  
publiques 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 apparaître sur la dernière image de chaque microfiche, selon le cas: le symbole  $\rightarrow$  signifie "A SUIVRE", le symbole  $\nabla$  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.

(All rights reserved.)

**ADVANCE PROOF**—(Subject to revision).

This proof is sent to you for discussion only, and on the express understanding that it is not to be used for any other purpose whatever.—(See Sec. 47 of the Constitution).

---

Canadian Society of Civil Engineers.

INCORPORATED 1887.

---

**TRANSACTIONS.**

N.B.—This Society, as a body, does not hold itself responsible for the facts and opinions stated in any of its publications.

---

**PORT CRESCENT AND HER BREAKWATER.**

By A. S. GOING, A.M.CAN.SOC.C.E.

To be read Thursday, 26th October, 1893.

In January, 1890, the Port Crescent Improvement Company was incorporated to build a town site at Crescent Bay, Clallam County, State of Washington.

Crescent Bay is located, geographically, in Latitude  $48^{\circ} 10'$  North, Longitude  $123^{\circ} 40'$  West, on the south shore of the Straits of Juan de Fuca, 40 miles east of the Pacific. It is a small bay, measuring about one mile east and west, by half a mile north and south.

It is the nearest point on the American shore to Vancouver Island, and there is the possibility of a railway ferry from Crescent Bay to Becher Bay on the Vancouver side.

A fine agricultural country adjoins it, and some of the finest timber belts in the State of Washington are in the immediate vicinity.

Operations were commenced in February, 1890, by laying out a town site on the bench above the bay, covering about 400 acres, the frontage between the town site and bay being reserved for railway purposes.

The town site was laid out on the rectangular plan; the streets being 80 feet and the avenues 100 feet wide.

Blocks were 200 feet by 300 feet; lots 30 feet by 100 feet. The tiers of blocks fronting on Crescent Avenue were given alleyways, 20 feet wide, the intention being to sell them as business blocks.

The streets were monumented every four blocks with stones planted below the surface, at street intersections.

An accurate topographical map was made, from which all the street grades were located.

Crescent Avenue was graded half width for its entire distance. A pipe line laid from one of the streams near by furnished water. After the town site survey was completed, the company set men to work, clearing the site and constructing a 50 foot roadway from the beach to the bench above.

The elevation of the town site at the north line, where the roadway enters Crescent Avenue, is 220 feet above sea level. At the south line of the town site,  $\frac{1}{2}$  of a mile distant, the elevation is 310 feet above sea level.

The roadway is 2,400 feet long, on a 9 p. o. grade, and was constructed by building cribwork to sustain the embankment, the roadbed being about  $\frac{2}{3}$  in excavation and  $\frac{1}{3}$  in embankment. The average slope of the hill is  $35^{\circ}$ .

The crib work was built of cedar logs, lapped and drift-bolted. An eight-foot sidewalk with hand rail and a box gutter were built on the outer side of the roadway.

A ditch three feet wide and eighteen inches deep was excavated at the foot of the hill slopes, thus reducing the roadway to about 38 feet for traffic purposes.

The material excavated was hard pan and clayey gravel with some rock. The total cost of the road was \$24,000.

The company advertised the work, but the tenders were all above the actual cost.

After clearing about half the town site, and completing the roadway, hotel, wharf and other company buildings, attention was given to the main scheme—that of enlarging and improving the harbour.

After making a thorough survey of the coast line for two miles east and west of the bay, soundings of the harbour were taken as follows: transit stations were established at different points on the shore; two transit men observing from different stations read angles at each sounding. The recorder in the boat would wave a white flag for each sounding, and at the end of 10 soundings would check the number by a blue flag, the observers on shore replying with a similar flag.

About two hours was as long as the instrument men could observe successfully, on account of the severe strain on the eyes. They recorded as well as read the angles on the verniers of the transits. Two Gurley Mountain Transits were used on the work. The boat crew consisted of engineer, leadsman, recorder, and two oarsmen. About 700 accurate soundings were taken and reduced to low water level, before being recorded on the map. The tide gauge was examined hourly while the soundings were in progress, and three times a day thereafter.

The bottom was found to be sandy, a few boulders being found near the shore where the hillsides showed rock formation.

The direction and velocity of the currents were also ascertained. The velocity of the current between the reef and headland on the west side was about four miles per hour, while on the east side it was much less.

At the entrance to the bay, the two reefs shown on the accompanying map were thoroughly sounded. The largest reef, located on the west side, being marked by a large mushroom buoy, set by the United States Light House Department.

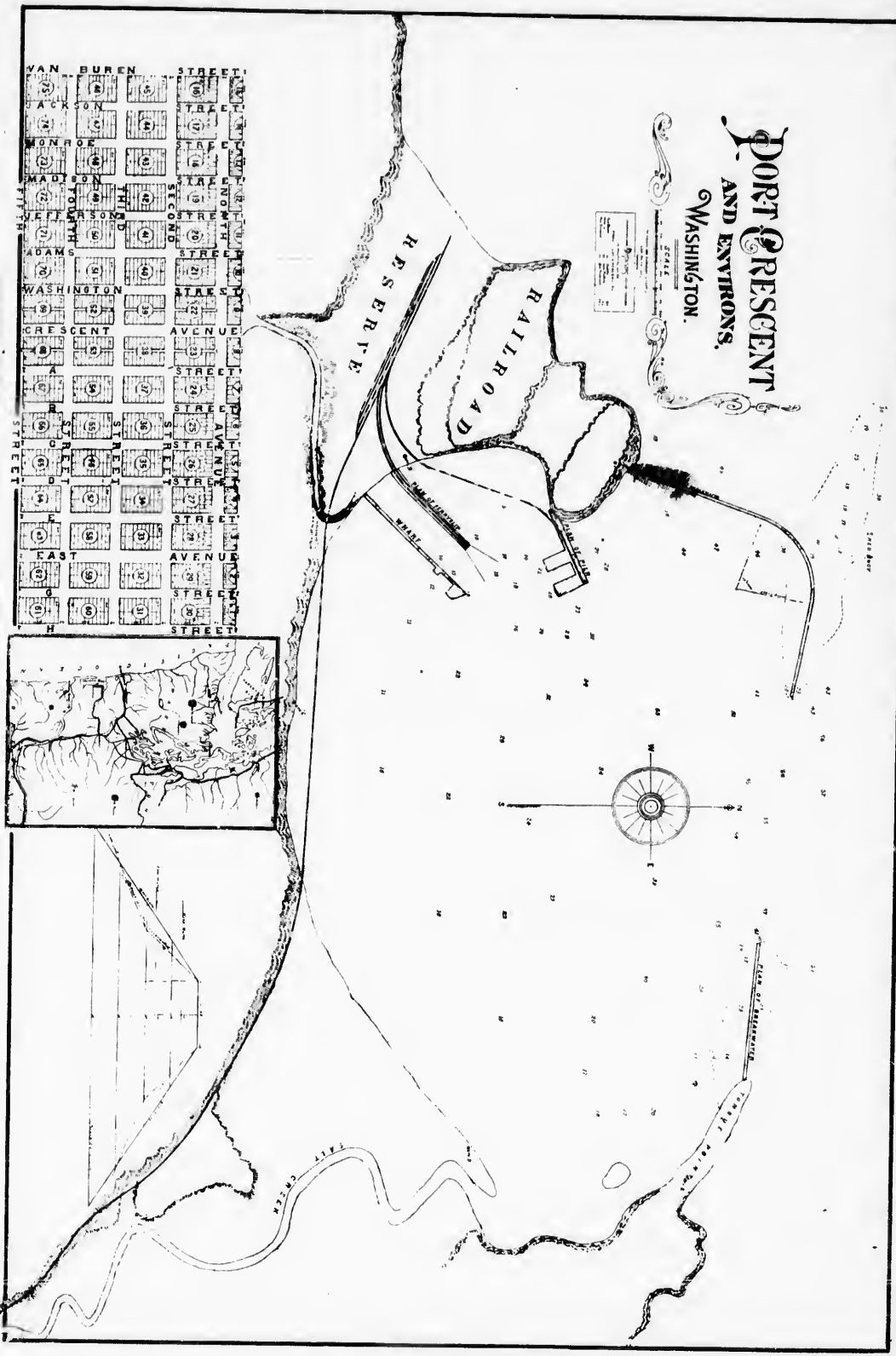
The idea was to connect the high headland on the west side of the bay with the reef, thus increasing the size of the harbour and protecting it from the heavy western swells which roll in during the winter season. The headland stands 103 feet above sea level, and is mostly solid rock. Tongue Point, on the east side, is a long low flat point, jutting out towards the reef, and was to be extended by a breakwater. Nothing has yet been done with this point. The breakwater on the west being the more important, all attention was directed to this point. It was to be a huge rock fill, 25 feet wide on top, with side slopes of  $1\frac{1}{2}$  to 1. The top was located 6 feet above high tide or 16 feet above low tide; 10 feet being the difference between high and low water.

In August, 1890, drillers were placed on the point where the breakwater was to commence, and a tunnel 4 feet by 4 feet, cross-section 78 feet long, with a T at the end 44 and 46 feet long, respectively, was excavated in the solid rock. The material encountered varied in hardness and texture, some being of a conglomerate nature, while other formations showed traces of iron. Three shifts of 8 hours each worked in the tunnel. The average cost was \$6.00 per lineal foot. Hand drills were used. In September, the powder arrived from San Francisco, and preparations were made to load the tunnel with 18,000 pounds of Black Powder and Judson No. 2. On account of a seam being found in the top of the hill, immediately above the tunnel, and fearing the blast might prove a "blow out" at the back, quite a number of springing holes were drilled in the face of the cliff, on both sides of the mouth of the tunnel.



# PORT CRESCENT AND ENVIRONS, WASHINGTON.

Scale  
1 inch = 100 feet  
1 mile = 3200 feet



VAN BUREN STREET  
JACKSON STREET  
MONROE STREET  
MADISON STREET  
JEFFERSON STREET  
ADAMS STREET  
WASHINGTON STREET  
CRESCENT AVENUE  
EAST AVENUE

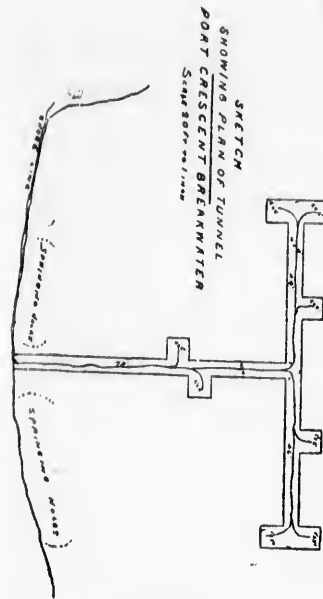
CHESAPEAKE  
CANAL

WASHINGTON  
AND ANAPOLIS  
RAILROAD



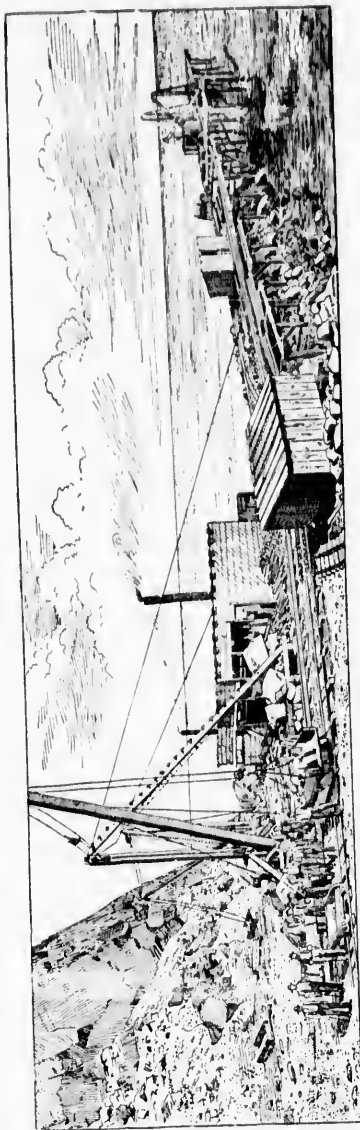






Wire were laid, so the shot could be fired by a battery 1200 feet away. On September 28th, 1890, all connections were made and the battery key sprung in; in a moment the work of days showed good results. The springing holes did the work designed for them; the huge mass fell forward and was thrown into the Straits in some places 150 feet from shore and in the line of the breakwater. A rough measurement showed that about 15,000 cubic yards had been displaced and at least 10,000 cubic yards loosened, ready for breaking and dislodging.

After the blast, preparations were made to commence the work of filling in the deep channel. Workmen began clearing a space to erect derricks and sheds for machinery. An average of 30 men were employed in drilling, breaking and wheeling rock. As soon as possible, racks were laid, and push cars with a capacity of  $1\frac{1}{2}$  cubic yards, were built. After the breakwater had been extended about one hundred feet from the shore line, piling was driven to facilitate the work. The bents were placed 15 feet apart, and consisted of four piles nine feet apart, swayed braced, and capped with  $12'' \times 12'' \times 32'$  sticks. 40 pound rails were laid on  $12'' \times 12''$  stringers, the track being double and narrow gauge width. Ties were not laid on account of the material being dumped between as well as on the outside of the stringer. A slight grade of about four inches per one hundred feet was given the bank, so that when cars were loaded, two men could readily handle them. The cars were built, so that they could be used for end or side dumping. The material handled contained about 5 per cent. gravel, and efforts were made to dump the earthy material on the west slope. The void space in the fill was estimated to be about 35 per cent., although, from the nature and size of the material placed in position,



it cannot be more than 25 per cent. The rock cubes dumped in place varied from 12 inches to 50 inches in diameter.

The average height of the rock bank will be 50 feet, with a width of 25 feet on top and side slopes of  $1\frac{1}{2}$  to 1, giving an end area of 5000 square feet or 185 cubic yards per lineal foot. Allowing 25 per cent. for voids, would give 139 cubic yards per lineal foot, to be dumped in bank. The average cost of the work thus far has been about one dollar per cubic yard, although some of the material has been handled for forty cents a yard. During construction, from 20 to 60 men were employed, the force being increased or decreased as the work demanded. The system of building the bank by erecting trestle-work and filling in with rock has proven the most economical. Work continued during the greater part of the year until November, 1891, when, owing to the financial depression prevailing on the Pacific coast, the company decided to suspend operations until some future time. At that time, the piling had been built out a distance of 405 feet from the shore, and the rockwork extended 300 feet. The severe storms of last year

carried away all of the unfilled piling, but the rock bank still stands firm. The general slope of the banks appear from rough measurement to be about 1 to 1 for 20 feet from the top, then curving to about 2 to 1 slope. The curved slope has been caused by the severe action of the breakers running in during western storms. Eventually the slopes will have to be filled to  $1\frac{1}{2}$  to 1, and on the west side 2 to 1.

Owing to the work being constructed in the Straits of Juan De Fuca, which have a general width of from 12 to 16 miles, and being 40 miles east of the Pacific Ocean, the dangers to be encountered in construction are not as great as if built upon the Atlantic or Pacific sea coast. The prevailing winds are from the west, although in January the "North Easters" are the worst, and last from one to three days. The currents sweep up the west coast, and shoot along the west side of the headland, then turn northerly towards the reef, before curving again to the east.

The soundings on the reef show a deposit of sand amongst the boulders. This action of the currents is noticeable at Port Angelis, 16 miles further east, where a curved spit, 3 miles long, has been formed. At Dungeness spit, 25 miles east of Crescent Bay, is also seen the same formation.

The works have now stood the action of three seasons, and no doubt when the banks are filled out to their original slopes they will be amply strong.

This enterprise has been entirely carried out by private capital, although it is expected, should the town ever amount to any importance, that the United States Government will complete the breakwater on a more elaborate scale. This enterprise is only one of the many projects started in the far West, and shows what money and energy are expended in building up the many hamlets and villages that now dot the Pacific States.

dumped in place

, with a width of  
end area of 5000  
ring 25 per cent.  
t, to be dumped  
s been about one  
us been handled  
0 to 60 men were  
work demanded.  
ork and filling in  
continued during  
when, owing to  
ast, the company  
e. At that time,  
t from the shore,  
orms of last year

