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the Degree of Bachelor of Science

THE LAYOUT OF A SHIPYARD

June 1920

George Arthur Wilson

Class of 1920
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INTRODUCTION

The object of this thesis is to determine an efficient layout of a shipyard for the construction of a combination passenger-freight steamer, which is two hundred feet long, thirty feet wide and nine foot mean draft.

The shipbuilding industry in America is young and the growth of yards has increased only as the demands for our ships have increased. Most of the present shipyards have evolutionized from the old-fashioned yards for building wooden ships. Many of them started with one or two buildings and they gradually increased in size as the volume of business increased. This resulted in a conglomeration of buildings scattered about with little regard for convenience or efficiency. For this reason it seems that a thesis treating with this subject will at least find service as a reference for suggestions. There is also a slight possibility that this thesis might form the basis for further investigations.

Investigation of several yards verified the fact that the yards are poorly laid out and that because of this the productive efficiency is materially decreased. This thesis will deal with the following subjects: the size and kind of ship, the choice of location, a survey of the site, the yard layout, types of buildings and several typical routings. An attempt is made to point out the advantages of the system used, over systems in existing yards.
SIZE AND KIND OF SHIP

For this work, it will be assumed that the ships to be constructed are two hundred foot steamers carrying passengers and about 175 tons of cargo. They have a moulded breadth of thirty four feet and a mean draft (loaded) of nine feet. The hull and strength parts are to be made of steel and the superstructure, which consists of three decks above the strength deck, is to be chiefly of wood construction. A complete record of the data for their construction is given in Appendix I.

LOCATION

A suitable location for the establishment of a shipyard must satisfy the following conditions:-

1. It should be urban or, at least, near a large city.
2. It should be on a navigable river or on a harbor where the difficulty of passing drawbridges would be obviated.
3. It should be near a railroad.
4. The means of communication should be good; that is, roads, train accommodation, etc.
5. It should not be too expensive.

To find a site which will satisfy all of the above conditions is not an easy task. After making a visit to the Massachusetts Waterways Commission at the State House, and being told by the engineer in charge that there was
no site available within ten miles of Boston, the proposition seemed to be a doubtful one. However the Lynn marshes proved a field for investigation. A careful study of the map and a visit to the marshes resulted in finding only one place which would approach being satisfactory.

This site is shown in red on the map in Appendix II. It is made land and partly surrounded by a temporary bulkhead; and owned by the city of Lynn. A visit to Lynn Chamber of Commerce revealed the fact that part of the land was given to the city of Lynn for the promotion of industrial development. This simplifies the matter of making the contract for purchasing or leasing the land as well as decreasing the cost. Of course just what would be asked for it, is indefinite, depending in part upon the vote of the Lynn City Council; but it is probable that the cost of filling in will be charged to the purchaser.

The site is less than one quarter of a mile from the Boston and Maine Railroad and only three hundred yards from the B. & L. Narrow Gauge Railroad. It is about seven minutes walk from the Narrow Gauge Railroad Depot and about twelve minutes walk from the B. & M. Depot at West Lynn.

It is located on the Lynnway Boulevard which is the main shore road from Boston to Portsmouth. The Narrow Gauge train service is very good; the trains running at fifteen minute intervals. During rush hours many regular
B. & M. trains stop at West Lynn. This makes it very convenient for workmen living in Lynn or between Lynn and Boston. The walk from the B. & M. Depot in Lynn takes less than half an hour; in fact, the site is ideally located from the standpoint of communication.

The location is also favorable in regards to water facilities. Directly opposite the site, there are mud flats at low tide, but the ship when launched will draw only eight feet of water, so this difficulty can be overcome by a little dredging. The southerly side of the plot is on the Saugus River which has a twelve foot channel at low water. This makes it necessary to do only a small amount of dredging for the fitting-out wharf.

After noting all the above considerations, it was deemed advisable to make this the site for the proposed shipyard. In fact, this site has many advantages over several of the local shipyards. It is to be noted that practically all the requirements for a good location for a shipyard are met.

**SURVEY OF THE LAND**

After deciding upon the location for the proposed yard, the next step in the work was to make a survey of it. Mr. P. M. Berko, 1920, of the course in Civil Engineering, very kindly volunteered his assistance in making the survey. The results of this work are given in detail in Appendix III.
The plot is about twice as long as it is wide and contains 1,048,000 square feet or about twenty four acres. The northerly boundary has been partially washed away by the tide because the bulkhead is broken so that it is only four feet above mean low water. The ground slopes upward toward the south forming a sandy beach. The southerly boundary is about twelve feet above mean low water, and the level at this end is several feet above the level of the State Highway. Three rough profiles are given on the layout plan in Appendix V.

The composition of the soil is open to question, but, since the site was filled in by hydraulic dredging, it is certain that the surface soil to a depth of ten or twelve feet is a mixture of sand, gravel and clay. Below this there are probably alternate layers of mud, sand and clay. The relative thickness of these strata are not known because it would be too expensive for thesis work to get the borings. However it is imperative that the constituents of the subsoil be known before the designing and constructing is done in order to determine the amount and kind of foundation. It is probable that the buildings will require floating pile foundations. A good sign that the ground is all right for building purposes is the presence of the Lynn General Electric Company, built on the same marsh about five hundred yards away. (see map App.I)
The preparation of the land for building is a simple matter. A substantial bulkhead should be placed across the northern boundary and this end of the plot filled in; preferably by hydraulic dredging from the harbor directly in front of the building ways, or from the southern end where the fitting out wharf is to be. The water, mud and silt should be returned by use of proper sluices. When this is finished the land should be in a condition ready for the actual construction.

THE YARD LAYOUT

The layout of a shipyard, like the layout of any industrial plant, requires a knowledge of the various operations and their relation to the finished product. The shipyard departs somewhat from the typical plant because there are many more departments and each is a unit by itself. In order to become more fully informed in this matter, the writer visited several local yards, including the Fore River Works at Quincy, the Victory Plant at Squantum, and the Charlestown Navy Yard. In addition, a study of many other yards in this country and abroad, (see list in Appendix V.) was made. The present layout embodies the ideas gained from this investigation; bearing in mind, of course, that although no two yards are laid out the same, the same principle applies to them all. It
may be stated: "Good transportation facilities, with re-
handling a minimum; and the various departments arranged
in relation to the building slips at radii increasing in
direct proportion to the lessening importance of the vol-
ume of the work."

Among the important matters which must be considered
are; the building ways, the fitting-out wharf, the princi-
ple streets, the railroads, the steel and lumber yards
and the layout of buildings. Each of the above items have
special requirements which require analysis before decid-
ing upon the location.

Let us first consider the location of building ways.
The first requisite is that they shall be placed where
the water is deep enough for launching and where checking
devices can be avoided. From the map in Appendix I, we
see that the easterly boundary is only a small amount
above mean low water. The ship draws eight feet of water
when launched, so there is sufficient depth for launching
at high tide. The ways should also be centrally located
so that material from all parts of the yard can be taken
direct to avoid excess handling. Because sub-permanent
magnetism is produced in a ship while on the ways, it is
advisable to have the ways run from east to west to elim-
inate this effect. Finally the ways should be placed
where the number can be increased if the expansion of the
yard makes it necessary. It is readily seen that the
middle of the eastern boundary of the site serves as the proper place.

If we assume that four ships are to be finished per year and that it takes about nine months to finish one under normal conditions, then four ways will be required. Additional ways may be placed just north of the others if necessary.

The fitting out wharf depends for its location on the depth of water, the only exception being where it is possible to have a wet basin. The problem of using a wet basin for this yard is out of question because it would be difficult to keep out the mud and silt from the marshes. The southerly boundary on the Saugus River is the best location because the water is deep and only a small amount of dredging is necessary near the shore. The wharf is to be 70 feet wide and 250 feet long. It is to be built on piles and equipped with a jib crane. A wharf for unloading lumber or supplies is also provided at this end of the yard. (see Layout)

The location of streets determines to a large extent the layout of buildings and visa versa. Without doubt a rectilinear layout is best. It is also true that the width of streets should be proportional to the amount of traffic on them. The street in front of the ways and running perpendicular to them is made the widest so as to allow sufficient space for assembling bulkheads, etc.
The street running parallel with the ways between the steel mill and the blacksmith shop is also wide because this direct passage to the ways accommodates considerable traffic. The other streets which have only a normal amount of traffic are narrower, but of uniform width.

Ease and rapidity of transportation are the deciding factors for laying out the railroads. Too much trackage is objectionable, but it is sacrificed where a gain in speed is evident. A space for storing cars is provided at the northerly end of the yard. The tracks pass within convenient range of all the shops, the storage yards and the fitting out wharf. The curvature of the tracks shown on the layout plan are only representative of direction and are not designed for the proper degree of curvature, which should not exceed twenty-one degrees for yard work.

The steel yard for plate and angle storage is placed at the southerly end of the steel mill where the material can be taken direct to the shops. The main railroad line passes through it and over head cranes unload the cars and place the material in the proper racks. The lumber yard is adjacent the lumber wharf and suitably placed between the joiner shop and the carpenter shop.

The water supply is to be obtained by piping from the nearest Lynn Water Main. It is necessary for the
yard to have its own sewage and drainage system. Emergency power and light can be had from the Lynn Gas and Electric Company whose lines pass the site.

In considering the layout of buildings for the yard, it must be remembered that all shops are to be arranged in sequence so that all material may be quickly and expeditiously handled. The fundamental principle, (stated at the top of page 8.) is to be followed as far as possible. It is therefore advisable to put near together those shops which depend upon each other for supply of material. It is evident and essential that shops making heavy parts be as near the ways as possible, because the boilers and machinery are preferably installed before the launching. Finally all shops should be so located that the raw material will pass direct from the storage yards, through the shops and to the ship for erection.

The foundations for buildings will vary with the load and the kind of work to which they are subjected, but since there is no data at hand concerning the soil, it is impossible to determine the kind and amount which is needed.

The buildings fall into two primary classes, wooden structures and steel structures. It is advisable to have buildings of the same size made the same type so as to save expense. The walls of the steel buildings are to be of glass. This gives the best light and with better
light, more efficient workmanship. The buildings will depend upon natural ventilation except the steel mill which will require a fan. The steel mill will be heated by the waste heat from the bending furnace but all other buildings will be heated by steam from the power house.

The size of buildings cannot be determined unless the amount and size of equipment is known. A satisfactory method for determining the equipment for a given shop is described and carried through by Mr. H. G. Stebbins, of M.I.T., 1917, in a thesis entitled, "A Shipyard Layout," but this method is only useful when extensive details are known; such as, the working capacity of the machines, the size of machines, the number of holes to be drilled, punched, reamed, the number of edges to be planed, etc. Without these details, an approximation for size will serve the purpose of this work. Assuming that the equipment was known, then too much emphasis cannot be laid upon the necessity of having an abundance of free space for storing and assembling the raw and finished work. At the Victory Plant at Squantum which made records for speed, the large amount of unused space was very noticeable and this probably influenced the rapidity of production by preventing congestion, and giving ample storage room.

The following is a list of the shops required in a modern shipyard. Each one is treated separately in detail in Appendix IV.
List of Shops

1. Plate shop
2. Angle shop
3. Mold Loft
4. Pattern shop
5. Foundry
6. Heat treatment
7. Boiler shop
8. Copper shop
9. Blacksmith shop
10. Pipe shop
11. Galvanizing shop
12. Joiner shop
13. Carpenter shop
14. Riggers loft
15. Acetylene welders
16. Paint shop
17. Repair shop

Shops

18. In addition to these shops there are to be buildings for:

1. Administration
2. Draughting
3. Power
4. Storage
5. Employment office
6. Lunch room
7. Fire protection
8. First aid
9. Tool houses
10. Crossing tender
11. Garage
SHIPMENT OF MATERIAL

The two principal materials used in a shipyard are wood and steel. The first of these will be shipped to the yard and unloaded on the lumber wharf. In foreign yards, there is a sawmill at or near the wharf but in this country the logs are all sawed before they are shipped. The steel may be shipped to the yard by boat or by freight. The latter method simplifies the handling because the steel is taken direct from the cars to the yard racks. All engine parts will be unloaded at their respective shops. Manufactured fittings, such as, pumps, winches, chains, rope and furnishings will be unloaded at the store house ready for installation on the ship. Cement, paint and other miscellaneous supplies will be trucked to the yard. Sand and pig iron for the foundry will be unloaded in bins provided for the purpose outside the foundry. In Appendix VI are given the alternatives for supplying the yard, together with the reason for the above choice.

EQUIPMENT

The equipment of the yard is to consist of modern standardized machinery. For transporting of material there will be a locomotive shifter and twelve flat cars. There will also be two locomotive cranes capable of lift-
ing ten tons, each on a twenty-five foot radius. The steel yard is divided into two bays, one for plates and the other for rolled steel. Each bay is equipped with two traveling cranes, one of which will operate chiefly inside the steel mill and the other in the yard. The building ways are provided with two cantilever cranes, each crane will accommodate two ways. The crane will have a capacity for 20 tons at thirty-five feet arm and 10 tons at seventy feet. The loads are balanced by a counter-weight which runs out from the pivot a distance proportion to the distance of the load. Additional weights must be added for heavy loads.

All the shops will be equipped with beam hoists and traveling cranes. Further details are given in Appendix IV.

ROUTINGS

Before explaining the routings, it will be best to refer to the routing plan shown in Appendix V. The red lines show the path of the material and the arrow-heads indicate the direction which it moves. The plan does not attempt to show the movement of material inside the shops, it simply indicates the direction through them. It is clear that in practically every instance the material has a direct course to the ways or to the wharf.
Most of the material used in the hull of a ship passes through the steel mill. The plates and angles are taken from the racks in the steel yard by the overhead traveling cranes and placed inside the building. It is laid out here and then passes on through the shop so that each successive operation brings it nearer the assembling space at the other end of the building. At this point, it is stored, or placed on flat cars and taken to the buildings ways. The finished plates and angles will then be taken by the cantilever cranes to the hulls, or they may be unloaded and stacked ready for erection by a locomotive crane, for erection.

The above method has a great advantage over many existing yards because the material passes direct from the steel yard to the building ways. It may be implied that the finished material should be taken from the shops by traveling cranes to the building ways. It cannot be done advantageously in the present layout, because one crane outside must accomplish the work of four inside the steel mill. Another feature of the method used is that the flat cars pass direct to the assembling space at the head of the ways. However, in case the cantilever cranes are over-burdened or "out of commission", provision has been made for carrying on the work by extending the railroad tracks into the space between the ships (space not occupied by cantilevers) and making use of the locomotive
dredges. If necessary they can be used in addition to the cantilevers.

The routings for engine parts are also direct. For example, the foundry is placed farthest of the engine buildings from the ways. This affords an opportunity for the raw material to pass toward the building ways during its fabrication. The sand, scrap, pig iron and flux are stored in bins outside the foundry. These are brought inside on trolleys and converted into steel. The castings are assembled at each end of the building; those going direct to the ways without machining are placed at the eastern end and those to be machined or forged at the western end. Here they are cleaned and snagged. Those which are to be machined are loaded on flat cars and unloaded at the machine shop. The castings are then finished and assembled at the other end of the shop. From here they are taken direct to the ships.

The other shops have storage and assembling spaces at each end so that the material can be taken readily from the store yards to the shops and then through the shops to the ways.

The chief advantage of this layout over many yards is that the buildings are near together. The machine shop and boiler shop which make the heavy material are near the ways thus reducing the amount of handling of these parts.
One of the interesting features of the yard is the direct routing of the joiner material and the carpenter or shipwright's work. The lumber yard is adjacent the wharf and the joiner shop next to the yard. Hence it is clear that the wood can be carried to the shop direct with little loss of time. Likewise the carpenter shop is near the yard and the lumber can be quickly brought into the shop for working. If lumber is required in quantity at either of these shops, it can be loaded at the yard onto flat cars; but if it is needed in small amounts, the shops are not too far away to handle it. It is clear that the finished joiner work can be stored at one end of the shop and quickly transferred to the fitting out wharf.

George A. Wilson
APPENDICES

In the appendices which follow has been placed data, plans, descriptions, etc., which are not of sufficient importance to warrant their being placed in the body of the thesis but which are closely connected with it.
APPENDIX I

SIZE AND KIND OF SHIP
The briefest way of stating the size and kind of
ship is in form of a problem. It is to be a ship which
confirms to the following conditions:

1. To carry 175 tons of cargo, fresh water, stores
and outfit of 10 tons.

2. To have a mean draft of not more than ninefeet
moulded.

3. To have sufficient horsepower to make 13 knots.

4. To be able to steam 500 knots at a speed of 13
knots.

5. To have a metacentric height of 2.0 feet.

6. The vessel to be the Single Bottom, Single Deck
Type, built to the requirements of Lloyd's.

7. The cargo to be mixed passenger and freight.

Constants

Length B. L. 2000 ft. Assume that G is 3' above
Beam extreme L.W.L. 34" L.W.L. or 12' abovevB.L.
Draft at F.B. 8" \((Go = V(d + Go))\)
Draft at A.F. 10" Coal per H.P.p.hr. \(C = 2.0\)
Mean draft 9" Aux. Coal per hr. \(g = 200\#\)
C. of G. Coef. 0.25 H.P. per ton mach. \(p = 6.5\)
Admiralty" 146.0
Additional Data

Freeboard (To the top of main deck at the side)

At the F. P. .................. 8. 6. 0.
At No. 5 ........................ 4. 8. 0.
At No. 7 1/2 .................... 4. 3. 0.
At the A. P. .................... 4. 10. 0.

Curve of Areas (for 1/2 body)  Area Sq. Ft.

Sta.  1/2 ........................ 17 1/2
    1 ............................ 41
    1-1/2 .......................... 66
    2 ............................ 87
    3 ............................ 119
    4 ............................ 133
    5 ............................ 130
    6 ............................ 111
    7  82 1/2
    8  ......................... 51
    8-1/2 .......................... 36
    9  .......................... 21
    9-1/2 ........................... 9

Basis of # 0 at C. C.
The ship before and after launching showing the general shape and the amount of woodwork in the superstructure.
APPENDIX II

LOCATION
LOCATION of the
PROPOSED SHIPYARD
ON
LYNN HARBOR
From a Survey of 1915
Scale:

FEET
B. & M. Freight Yd.

PROPOSED LOCATION

SAUGUS

LYNN HARBOR

RIVER
APPENDIX III

DATA OF A SURVEY
The survey of the proposed location was made on December 23, 1919. The site did not have definite boundary lines, which meant that the size could not be obtained with great precision even if that were required. Accordingly, we simply made a stadio survey. A low fog hung over the site and the temperature was slightly above freezing. This necessitated taking a number of short "shots" until the fog lifted at noontime, when longer ones were taken.

The precision of this work is fair and the check given by the Double Meridian Distance Method for finding the area, shows conclusively that a stadio survey was sufficient.

The tables which follow give the data and computations for area.

The area as calculated is about 24 acres.
### TABLE I

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<th>Angle</th>
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<td>A</td>
<td>0° 00'</td>
<td>188</td>
<td>S 75° 1/2 E</td>
</tr>
<tr>
<td>B</td>
<td>0° 00'</td>
<td>203</td>
<td>S 75° 1/4 E</td>
</tr>
<tr>
<td>c</td>
<td>38° 06'R</td>
<td>258</td>
<td>S 37° E</td>
</tr>
<tr>
<td>a</td>
<td>0° 00'</td>
<td>157</td>
<td>S 22° 1/2 E</td>
</tr>
<tr>
<td>d</td>
<td>40° 26'L</td>
<td>204</td>
<td>S 31° W</td>
</tr>
<tr>
<td>e</td>
<td>22° 10'L</td>
<td>278</td>
<td>S 30° 1/2 W</td>
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<td>g</td>
<td>14° 26'R</td>
<td>578</td>
<td>S 88° 1/2 W</td>
</tr>
<tr>
<td>h</td>
<td>53° 05'R</td>
<td>548</td>
<td>*</td>
</tr>
<tr>
<td>k</td>
<td>180° 00'</td>
<td>22</td>
<td>N 28° 1/4 E</td>
</tr>
<tr>
<td>J</td>
<td>25° 50'L</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>j</td>
<td>19° 40'R</td>
<td>734</td>
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<td>L</td>
<td>43° 35'R</td>
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<tr>
<td>L</td>
<td>60° 02'L</td>
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</tr>
<tr>
<td>m</td>
<td>120° 04'R</td>
<td>828</td>
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</tr>
<tr>
<td>l</td>
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</tr>
<tr>
<td>n</td>
<td>180° 00'</td>
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</tr>
<tr>
<td>A</td>
<td>74° 42'R</td>
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* Too foggy to get reading.

m Southerly corner of the stone pier on the Lynn side of the bridge over the Saugus River.

Sketch

(not to scale)
## TABLE II

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<td>x 824.3</td>
<td>1,241,396,</td>
<td>+</td>
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= 944,584 sq.ft.
### TABLE III

**Calculation of Additional Areas (by triangulation)**

<table>
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<tr>
<th>Base</th>
<th>Half Alt.</th>
<th>Area</th>
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<td>1733</td>
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<tr>
<td>188</td>
<td>2</td>
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<td>280</td>
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<td>95</td>
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<td>690</td>
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<td>100</td>
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<td>650</td>
<td>51</td>
<td>33,150</td>
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</table>

103,231 total additional area
944,584
1,047,815 Total Area sq. ft.

\[
\frac{1,047,815}{43,560} = 24.1 \text{ Arcs}
\]

The precision of the above computation cannot be relied upon within three or four percent because the distances were scaled from the plan and because the exact boundary lines of the plot could not be determined on the ground. However, for the purpose in hand it is all that is to be desired.
COMPUTATION

(A) log 1712 = 3.23350
log sin. 28°4 = 9.67545 - 10
Dep. dis. = 810.3
log 1712 = 3.23350
log cos 28°4 = 9.94492 - 10
12. 17842 - 10
Lat. dis. = 1608.0

(B) log 188 = 2.27416
log sin 14°2 = 9.98594 - 10
12. 24010 - 10
Dep. Dir. = 182.0
log 188 = 2.27416
log cos 14°2 = 9.39860 - 10
11. 67276 - 10
Lat. Dir. = 47.07

(C) log 258 = 2.41162
log sin 37° = 9.77946 - 10
12. 19708 - 10
Dep. Dis. = 155.3
log 258 = 2.41162
log cos 37° = 9.90535 - 10
12. 31397 - 10
Lat. Dis. = 206.1

1500 X 103.3 = 1,543,430
1833 X 47.1 = 86,371.98
1999 X 974.7 = 1,948,522.8
721.5 X 19.2 = 13,852.8
2177.5 X 206.6 = 4,459,871.5
2,445.6 X 258.4 = 631,943.6

(E) log 278 = 2.44404
log sin 22°4 = 9.96562
12. 40966
Dep. Dis = 257.8
log 278 = 2.44404
log cos 22°4 = 9.58284
12. 02688
Lat. Dis = 106.4

(I) log 1126 = 3.05154
log sin 56°4 = 9.93643
12. 98797
Dep. Dis = 972.7
log 1126 = 3.05154
log cos 56°4 = 9.70224
12. 75378 - 10
Lat. Dis = 567.3

(L) log 784 = 2.86570
log cos 28°4 = 9.99985
12. 86553 - 10
Dep. Dis = 733.4
log 784 = 2.86570
log sin 14°2 = 8.41742 - 10
11. 28362 - 10
Lat. Dis = 19.2

38°06'
14°26'
53°05'
57°36'
165°13'
360°
165°13'
194°47'
120°04'

74°43' computed closing angle
74°42' actual angle
APPENDIX IV

SIZE AND KIND OF BUILDINGS
It is probably advisable to treat with each building of the yard separately, stating their size, type of structure and briefly the kind of machines and equipment in them. Although the actual number of machines required is not known, and can only be obtained by extensive calculations and by securing details of their working capacity, the kind of machines will be all that can be mentioned in the limited time.

The buildings fall into two main classes, wood and steel. The wooden buildings will be made to comply with the Lynn fire laws as well as the state laws. Additional fire protection will be provided in order to increase the insurance. All structures will be well lighted and ventilated.

**Administration and Draughting**

A two story wooden structure 94 feet by 100 feet has been selected as suitable to accommodate the offices and draughting rooms for the yard. The first floor will have offices for; - Naval Architect, Chief Hull Draughtsman, Chief Engineer, Chief Engine Draughtsman, Clerks, Paymaster, Computers and Stenographers. There will also be a dark room and a blue print room. The offices will contain the usual office equipment.
The second floor will be used exclusively as the drafting room and the plan room. The hull force will be separated from the engine force by a partition but both will have access to the plan room as shown in the sketch below:

![Sketch of plan room layout]

Large skylights are provided over the middle of each room. The building is properly placed centrally in the yard and near the mold loft.

**Employment Office**

This will be a small single story structure about twenty-five feet square. It is located near the entrance and equipped with modern office equipment.

**Lunch Room**

The lunch room is a single storied structure and located as indicated on the layout plan. It will use the cafeteria system and have a capacity for three hundred at a seating. A sizable lunchroom is desirable because the yard is isolated from restaurants and there is no
Acetylene Welders Shop

Because of the extensive use of acetylene welding in this country, it seems advisable to create a separate department for it with headquarters in a single story wooden building about fifty by thirty feet. The structure is large enough to serve for storage for tanks and supplies as well as having an office for dispatching the welders. To facilitate and minimize the handling of tanks this building is centrally located. It will be provided with racks for tanks and a repair shop.

Carpenter Shop

This structure is properly placed near the lumber yard. It is a two story wooden building eighty by one hundred and twenty feet. The second floor will be used as the riggers loft. The carpenter shop is to be equipped with band and circular saws, planers, drills, hand tools, and other wood-working machines. There will also be a tool house and ample space for storage.

Repair Shop

This shop is located as shown on the layout plan where it is easily reached by all the shops. The equipment will consist of miscellaneous machinery for repair work.
Steel Mill and Mold Loft

As it was pointed out in the body of the thesis, the determination of the size of a structure for a given purpose, is mainly a question of having reliable data. The size is therefore chosen by assumption. This building will be 200 feet by 300 feet. It will contain the angle shop, plate shop, and mold loft.

A sketch of a section is shown below;

The structure is properly placed near the steel yard and near the building ways to facilitate the speedy passage of material to the ships. There is a great advantage in having the mold loft over the steel mill because templates are readily accessible at any time.
The steel mill will be equipped with the following machines: drills and countersinks, punches, shears, planers, bending rolls, hydraulic flanging machines, forges and special machines. The angle shop will have the furnaces and bending slabs; also a large hydraulic press for joggling or flanging. These machines are to so arranged as to facilitate the passage of material through the shop.

The mold loft will have the full size body and shear plans on the scrive board. One side of the loft will be used for storing template. There will be drills, saws and planers on this side also.

Blacksmith Shop

This structure is to be two stories high, 200 feet long and 100 feet wide. The second story will be used as a pipe shop. The building is well placed near the steel mill and also near the machine shop. The blacksmith shop will contain numerous hand forges and drop forges.

Machine Shop

This building is the same size and shape as the blacksmith shop. The second story will be used as an electrical shop. The structure is properly placed between the foundry and the blacksmith shop because the
supply of material comes from them to be finished. The engines are assembled here prior to installation and because the shop is near the ways handling is reduced to a minimum.

The shop will be equipped with modern machine tools. A feature of the shop will be that each machine will have individual electric drive. This has many advantages over the belt system because it saves time, accidents and energy. Lathes for turning out small parts will be placed on the second floor in space not used for electrical work. The machine shop will contain the following machines: engine lathes, plain and universal, milling machines, vertical milling machine, horizontal and vertical boring mills, shaper, planers, hand and automatic screw machines, turret lathes, universal grinder, slotter planer and tool cutter grinder. The shop will also be equipped with a twenty ton traveling crane.

**Foundry and Boiler Shop**

The sketch on the next page shows roughly the arrangement of these shops looking toward the ways. The structure is to be two stories high and two hundred feet square.

The foundry will be equipped with a bessemer converter, two cupolas and an open hearth furnace. An overhead trolley system will be used for distributing the molten steel to the foundries. A small portion of the foundry will...
molten metal. A small portion of the foundry will be isolated for core making. Bins for sand, pig, and flux are adjacent the structure and the scrap iron is piled opposite it.

The pattern shop, heat treatment plant, copper shop and galvanizing shop are placed on the second floor. Each is equipped with the usual apparatus. The shops are well placed at the end of the yard where there is sufficient room for storage.

This is to be a two story structure 100 feet wide and 200 feet long. This will be sufficiently large to turn out the finish work of the ship. The elaborate superstructure, mouldings, etc., are made in it. It is suitably located near the lumber yard and near the
fitting out wharf because most of the joiner work will not be erected after launching. The shop will be equipped with up-to-date machinery. The second floor will be used for light work and for storage.

Paint Shop

All paint, putty and cement will be kept in a steel fireproof structure fifty by seventy feet. The red lead will be kept in the carpenter shop because it is non-inflammable and because it is better placed near the building ways and the steel mill. The structure is placed near the wharf since most of the finish painting is done after launching.

Store House

For storage of miscellaneous fittings and supplies, purchased outside the yard, such as; auxilliary engines and pumps, motors, anchors, chains, rope, windlasses, etc, there will be a reinforced concrete building 100 feet wide and 140 feet long and three stories high. A loading platform will be provided at one side as shown on the layout plan.

Power House

It is a difficult matter to determine the size of
a building to accommodate the electric generators, steam turbines, condensers, boilers, air and hydraulic compressors and auxiliaries. A structure 100 feet by 94 feet is assumed sufficiently large. Fuel oil will be used instead of coal, two tanks are located near the building for storing it. The exhaust steam from the auxiliaries will be used for heating purposes throughout the yard. The plant is centrally located to minimize the amount of piping.

**Fire House and Garage**

Since the yard is isolated from Lynn, the yard will be equipped with an autochemical and an ambulance. Both will be kept in the garage but separated from the trucks by a fire wall. The structure will be one story high and made of brick.
APPENDIX V

PLANS

1. Layout of yard
2. Typical routings
Method of Procedure

The first step in finding an efficient layout was to determine the different shops needed and then to group them according to their relative importance. Several layouts were made, seven in all, and the routings marked on each. Uniform sized buildings were assumed in these preliminary plans. Then after deciding which of these plans was the best, the size of the actual structures were assumed and the proposed layout made, as given in this appendix.
KEY TO LAYOUT PLAN

1. Foundry, pattern shop, heat treatment, boiler shop, galvanizing shop, copper shop.
3. Blacksmith shop, pipe shop.
4. Steel mill, plates and angles, mould loft.
5. Steel storage yard.
7. Lumber yard.
8. Carpenter shop, riggers.
10. Store house.
11. Employment office.
13. Administration, estimating, and drafting rooms.
15. Acetylene welders.
17. Paint shop.
18. Storage.
19. Fitting out wharf.
20. Lumber wharf.
22. Storage.
23. Freight car storage.
24. Lunch room.
PLAN OF LAYOUT
OF THE
PROPOSED SHIPYARD

LOCATION OF ALL IMPORTANT FEATURES
SCALE IN FOOTS

S & H R.R. BRIDGE

MARPED DRAINS BY S & H R.R.

STONE PILL

KEY

Railroads
Crane rails

BY GEORGE A. WILSON
APPENDIX VI

MISCELLANEOUS

1. Preparation for thesis
2. Shipment of material
3. Bibliography
(1) YARDS STUDIED AND REFERRED TO FOR THIS WORK

American

Charlestown Navy Yard, Charlestown, Mass.
The Victory Plant, Squantum, Mass.
Fore River Works, Quincy, Mass.
Portsmouth Navy Yard, Portsmouth, N. H.
Bath Iron Works, Bath, Maine.
Sun Shipbuilding Plant, New York.
New York Shipbuilding Plant, Camden, N. J.
Maryland Steel Company, Sparrows Point, Md.
Union Iron Works, San Francisco.
Newport News Shipbuilding Co. & Drydocks, Va.
Hog Island (fabrication) Camden, N. J.
Newark Bay       "       Newark, N. J.

English

Penhoët Shipbuilding Co. Greenock, on the Clyde, Eng.
Scott's Ship. Co.          "          "          "          "          "
Beardmore and Company, Dalmuir, Scotland.
Yarrow Shipbuilding Co., Barrow in Furness, Eng.

German

Germania Werft, Kiel, Ger.
Vulcan Works, Hamburg, Ger.
Slohm & Voss, Shipbuilding Co., Hamburg, Ger.
There are at least six alternatives for the supply of material to the proposed yard. To determine the best plan for this yard, it will be advisable to treat each one separately. The cases will be considered from the standpoint of expense and facilitation of efficient movement of material.

The first method depends upon conditions embodied in a rumor. It has been inferred that, at some future time, the present Narrow Gauge Railroad will change its tracks and combine with the B. & M. R. R. on a spur just south of the Saugus River, because only two of the four standard gauge tracks are being used. If this were done, it would be a simple matter to make a spur from the main line near the West Lynn Station, thence southward along the fill now occupied by the Narrow Gauge Tracks to the yard. Since this plan depends on a questionable condition it is not satisfactory, although the case would be greatly reduced.

The second method is to build a trestle and two overhead bridges from the B. & M. R. R. over the Narrow Gauge Railroad and the Lynnway Boulevard to the yard. This plan is too expensive.

A third case, which is a possible one, consists in trucking the material in automobiles from the B. & M. R. R.
Freight Yard. It is less than half a mile away and there is a direct route to the yard. This plan is a feasible one but it is too expensive and does not permit of expansion of the yard.

The fourth proposed plan consists of loading the freight cars onto a ferry from a spur track just south of the Saugus River and towing it to the yard. The method is too expensive and inconvenient. A tug must be owned or hired by the yard and it must pass two drawbridges. The ferry can only be used at high tide on the Saugus side of the river.

The fifth case is to ship by freighters direct to the yard wharf. This is the cheapest method but it is not expedient because the supply might be curtailed in the winter. However it is advisable to have all lumber shipped direct by schooners to the yard.

The sixth and best plan consists of spurring directly from the main line near West Lynn Station as shown by the dotted red line on page 25, Appendix II. It would be necessary to widen the fill now used by the Narrow Gauge Railroad, or make a new fill, and have a grade crossing near the yard as shown on the plan. This method will be used to get the supplies to the yard because it is simple and cheap.
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