Report on Study Leave

January - April 1979

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INTRODUCTION

The work described in this report was funded by the following grants and I would like to acknowledge their support.

1. Thailand - Australian Department of Foreign Affairs
   Royal Danish Embassy - Thailand
   Silpakorn University

2. Kenya - Australian Research Grants Committee
   Leyland Australia
   T.V. Channel 7, Perth
   John Holland Trading Co.

3. Europe - Australian Research Grants Committee
   Western Australian Museum

4. U.S.A. - Western Australian Museum

The majority of this work was carried out during my long service leave, the Western Australian Museum, however, kindly granted official leave during the periods where I was working on research directly related to the Batavia project.

The main areas of study were as follows

1. Thailand

To give a one week lecture course at Silpakorn University, and a two week field excavation project, as part of a student training program. The excavation work was carried out on the Ko Kradat wreck-site, in the south east of the country. During the final period in the country, an inspection of the Pattaya wrecksite, was made, and an inspection of the Ko Kram wreck material. Through negotiations with the Thailand Sub-Aqua Club, a small volunteer maritime archaeological association was also established which it is hoped will work i association with Silpakorn University.

2. Kenya

This was the third season that this author has been involved in this excavation. The project this year included participation of three additional volunteers from Australia. Due to ill health, Mr.

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An additional research project involved developing a computor program for underwater survey work.

3. Europe

(a) Netherlands

Research here was involved in looking for historical information relating to the Batavia building facade, and additional information to help with the reconstruction. Research also covered a number of minor topics including, details related to the composite cannon, gun carriages, the ship Batavia building regulations and the Zuytdorp. Additionally, standard and stereophotogrammetric recording was carried out on the mid 17th century Zuiderzee wreck E81 at Kedelhaven.

(b) Germany

A visit was made to the Bremerhaven museum to examine the 14th century cog, which has been reconstructed and is about to be immersed in a PEG tank

(c) Denmark

Tojhuismusem Kopenhagen. This museum has an extensive military gun and cannon collection.

(d) Sweden

i. Vasa varvet, where standard and photogrammetric recording was carried out on the stern section of the Vasa

ii. Karlskroner Museum, which has an important section of a mid 17th century ship double planked like the Batavia.

iii. Malmo maritime and technical museum to visit Catharina Ingelman-Sundberg.

(e) United Kingdom

Visits to Captain Cook Exhibition, the Great Britain. Discussions with R. Sutcliff, Chairman of Council of Nautical Archaeology, B. Dolley, Editor of the Mariners Mirror, C. Martin, Director of

Zuytdorp. Additionally, standard and stereophotogrammetric recording was carried out on the mid 17th century Zuiderzee wreck E81 at Kedelhaven.

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2.1 Thailand

In November 1978 I was invited by Dr. Pensak Howitz of Silpakorn University, Bankok, Thailand, to conduct a training program in underwater archaeology for a group of students. This program initially was organised by SPAFA, and included students from Thailand, Singapore, Indonesia and the Philippines. The lectures were carried out during the first week of January 1979 at Silpakorn University. Subsequently a field excavation training program for the University students, was organised by Dr. Pensak and with assistance of divers from the Royal Thai Navy. The wrecksite selected was near the island of Koh Kradat, one of the most southerly islands of the eastern seaboard of Thailand, quite close to the Cambodian boarder. The site lay in shallow water (2m deep) off the northern end of the island. The wrecksite, which consisted of a large ballast mound together with scattered coarse stoneware shards, was surveyed using standard trilateration techniques. An excavation was carried out across the wrecksite in a trench 2m wide. This trench was excavated by hand in 2m grid squares; a record being made of all ballast stones, and ceramic artifacts recorded from each square. A number of complete fine stonewares and earthenwares of the Sukothai period were recovered together with many shards. An excavation report has been prepared (See Appendix 4.1). The excavation was an ideal opportunity to train students, since the site was in shallow water where long periods of labour intensive work were possible

The students were of a high standard, and were all keen and enthusiastic. The facilities were excellent and the only real problem was that it was difficult to adequately supervise the students alone. Thus for example, in future, I would strongly recommend having two more trained and experienced staff on hand to instruct in photographic recording, technical drawing and recording. The Ko Kradat site is only partially excavated and I would further recommend that an excavation trench be run across the site at right angles to the one we excavated. The work on this site could be greatly facilitated with the use of an induction waterdredge.

On return to Bankok, I was invited by Mrs. J. Martinusen, secretary of the Thailand Subaqua Club to dive on the Pattaya Wrecksite, south east of Bankok. The inspection of this site showed that looti[ng] was taking place, in fact when we arrived a team was just finishing working with an induction water dredge. The wrecksite is in a depth of about 30m where large ceramic Swanghalok storage jar sherds could be seen over the whole site. At least two complete jars were seen buried in the sand. A large section of very well preserved hull structure was noted. This site is under severe threat, and there is an urgent need to record the complete hull structure. The site could be treated as a rescue excavation and with a small team (c. 10), could be excavated and recorded in a matter of a few weeks.

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Initially the Ko Kram site was thought to be 14th century. More recently this estimate has been revised to the 15th-16th century, but it now appears that if this material is Swanghalok then considerable revision in this chronology is necessary, particularly as the Swanghalok kilns were thought to have been destroyed by the Burnese at the end of the 16th century.

2.2 Kenya

1979 was the third excavation season on the Santa Antonio de Tanna. On arrival in Kenya, I found the director Dr. R. Piercy, of INA, in hospital suffering from an infected foot. I was therefore asked, as I had three seasons experience of excavation on this site, to take over the direction of the work. This to some extent curtailed my work recording the hull structure, however, it was clear if I did not take on this responsibility it was unlikely that the excavation of the bow section would be completed in the season. There were only two other people on the excavation who had experience of the site before, one being N. Sander from the Conservation Laboratory of the W.A. Museum. The first phase of the operation was to clear a large concretion of cannon balls. This was done using small 100 gram explosive charges to break the concretion up. It was found that this size charge, nearly ten times that used on the Batavia, was optimum to break the concretion up and extract the cannon balls. About 370 intact shot were extracted.

The clear water period corresponding with high water spring tides was not due until the end of February, so excavation proceeded as rapidly as possible to clear the inside hull so that the structure could be photographed, during the clear water period. Once a reasonable amount of the interior of the hull was uncovered, I started recording the hull profiles. From the previous years experience on profile recording (See Appendix 4.2), a new type of profile recording machine was used. This consisted of an inverted triangle made out of mild steel tubing. A tape was glued onto the hypotenuse of the triangle and the whole clamped onto the keelson. Thus instead of using a circular protractor, as in the previous years, angle measurements were taken from the tape. The profile data was put onto the small Tl 59 computer and the rectangular co-ordinates of the profile calculated. Since the triangle system approximately doubled the accuracy of the previous system, much more accurate profiles were recorded this year. The profiles were made at 1 meter intervals, and two additional divers were taught to operate the system and record the data. Once the whole forward area was cleared and the inside of the vessel uncovered from the mast step to the bow section, the light sand and silt was removed in preparation for the photographic and photogramme-

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The season was marked by a singular lack of artifacts, once again indicating that the site was extensively salvaged at the time of her loss. The internal excavation of the hull is now complete, and it is planned next year that an excavation around the downward area outside of the hull should be carried out. It seems that my involvement, which has been purely to record the hull structure is now at and end. The small Tl 59 computer has proved to be a extremely versatile instrument for this type of work, and a brief paper on its applications is being prepared (See Appendix 4.3). Whilst I was in Mombasa, I was approached by Mr. O. Bawana, of Fort Jesus Museum, who asked if it would be possible for one of his staff, Mr. S. Mohammed could work in the Department of Maritime Archaeology to gain more experience in our type of work.

2.3 Europe

2.3.1 Netherlands

The first part of my work here was involved in research relating to the Batavia building facade. The first fort at Batavia was started in 1619. A plan sent to Holland and dated 7 October 1619 shows the old fort of Jacarta and Coens new plan. This forte was built initially with stone bastions on the inland side (south), the points Robyn and Diamont and earth bastions on the seaward (north) side the points Paerel and Saphyr. There was a land port on the south side, but initially there was no curtain wall between the two seaward bastions. This situation is shown in the plan in the West Friesland Museum dated 1627. An earth-work was constructed between these two points in 1628, as can be seen in the plan of Frans Floris Van Berkeroode. We now come to the plan showing Batavia under seige by the Javanese. This plan was originally found in the publication by Commelin, Begin and Voortgang van der VOC, published in 1646. I found that the illustration was taken from an earlier publication by Peter van den Broeck entitled Korte Historiael ende Journaelsche published in 1634 in Amsterdam. Van der Broeck was in Batavia in 1629. Throughout his published journal are engravings of places and scenes that he experienced. The engravings were made by Adriaen Jacobsz Matham the son and pupil of t more famous engraver Jacob Matham. A.J. Matham did not visit the Indies (according to F.W.H. Hollstein, who catalogued most of the famous 17th century engravers) and was living in Haarlen from 1623 to 1640. Matham must have been given illustrations by van den Broeck of the town of Batavia which included the now almost complete fort, with the seaward wall complete and the waterport still with scaffolding in place. It is my opinion that there can be no doubt that the port on the Batavia was intended for this incomplete gateway. Coincidently Van der Broeck in our type of work.

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however, certainly taken from a much earlier source. There were a number of other sources (See Appendix 4.4) which I was able to examine in the given time, I hope to arrange to get copies of these and other relevant information. There appears to be another interesting side line to this. In the Oude Batavia Gedenkboeck, reference is made to the destruction of the main gate of Batavia in 1751 and the sale of the carved stones with the companies coats of arms. These stones went to the fort Niew Victoria in Ambon, and are still in existance today. It is not clear what is meant by the main gate. Originally the main gate would have been the land port, however, by the 1630's the land gate was of less importance because of the extension of the fortified city walls to the south. The main entrance would have been more likely to have been the waterport, and this is reflected in the rather grotesque new waterport of 1756. I have visited Ambon and have photographs of the gateway of Fort Niew Victoria. Appendix 4 gives list of illustrations of the Castle of Batavia.

Research into the composite cannon from the Batavia showed that a special company was formed in the 1620's to manufacture these unique guns.

In discussions with Mr. J.P. Puype of the Scheepvaart museum advice was given about suitable gun carrages for the Batavia Vergulde Draeck cannon and the James Carronade. Mr. Puype feels that is is most important that the gun carrages which may be used to mount our cannon should be as authentic as possible. Appendix 5 gives drawings and constructional details of carrages.

A number of references to the building of the Batavia have been located by Ms. Lous Zuiderbaan, these relate to the resolutions to build the ship. Also she indicated a hitherto unrecorded list of the material salvaged by Pelsaart from the Batavia.

During my stay in the Netherlands, I carried out stereo photographic recording of the mid 17th century hull from the Zuiderzee excavations, known as E81. This is one of the 4 known 17th century hulls in existance (the others being the Santa Antonio de Tanna, Batavia and Wasa). The recording technique used was developed by this author and consists of two Nikon F cameras, mounted one metre apart on a stereo bar. The lenses used were 24mm, and a 1 metre callibrated grid square was used as a control. The recording concentrated on the stern section, and the construction of the supporting frame work.

Due to lack of time I was unable to carry out any research on

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2.3.2 Germany

On the way from Sweden to the Netherlands, I visited the Bremerhaven Scheepsvart Museum. Here they have a new museum, which, as a centre part of their display, is the 14th century Bremerhaven cog. The vessel is a very large and impressive 30m vessel, which virtually intact, with much of the superstructure surviving. When the ship was excavated, it was dismantled and sent in wet tanks, from its discovery site at Bremen, to the new museum at Bremerhaven. The timbers were kept wet and the whole has been reconstructed, untreated, under water sprays. It is invisaged that a huge stainless steel tank will be built around it and the intact rebuilt ship will then be treated in PEG.

The vessel stands on its keel, whilst the sides of the hull are supported with a large stainless steel frame running around the inside of the vessel which itself is supported from the roof of the building. No side trusses are used, and this gives a really good impression of the ship, uncluttered by supporting framework.

2.3.3 Denmark

The Tojhiusmuseum Kopenhagen contains a very interesting collection of firearms. Of particular interest were the 17th century Finnbanker cannons. These cannon which were made in Sweden are the same type as those found on the Vergulde Draeck. One in particular, from the Enighiden (1658) has a contemporary gun carriage which should be used as a basis for a reconstruction for a Vergulde cannon gun carriage Examples of firearms contemporary with the Vergulde Draeck and Batavia were also examined. There is also a 'leather' cannon in this museum dated to 1630, which has been suggested as another attempt, like the Batavia composite gun, to produce cheap firearms.

2.3.4 Sweden

Wasa varvet

I visited the Wasa during the Easter period, and was most kindly given permission by Mr. A. Kvarning, the director to work on the ship over this period. The photographic and photogrammetric recording concentrated on the stern quarter of the ship. Both internal and external recording was carried out, to determine the basic construction similarities of the vessel compared with the Batavia. Since the ship was built in the same year as the Batavia this is a most important and

then be treated in PEG.

The vessel stands on its keel, whilst the sides of the hull are supported with a large stainless steel frame running around the inside of the vessel which itself is supported from the roof of the building. No side trusses are used, and this gives a really good impression of the ship, uncluttered by supporting framework.

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I also examined the Wasa gun carrages which again should be used for the basis of any Batavia gun carrages. It should be emphasised that the gun carriages used at present for the bronze guns from the Batavia are not only incorrect as gun carriages but also not historically accurate.

Karls Kroner Museum

The Karlskroner museum is located on the south east corner of Sweden. The museum has part of the 17th century Swedish warship Carolus XI. The timbers does not seem to have been conserved, although they are in good condition. The structure consists of a 5m section of the side of the ship. Interestingly the structure is double planked as the Batavia and this to my knowledge is the only other example of this type of ship construction known. There are a number of constructional similarities to the Batavia and these were recorded photographically. There were also a number of interesting displays showing shipwrights tools and blockmakers equipment.

Malmo Museum

On arrival in Sweden, I visited Catherina Ingelman-Sundberg, who recently left the Department of Maritime Archaeology to take up an appointment as head of the Maritime section of the Malmo Museum. The maritime museum has only recently been opened, and Catherina is actively engaged in setting up the museum display. Their collection includes a submarine and a naval highspeed patrol boat.

2.4 United Kingdom

During my visit to the United Kingdom I was invited by Mr. R. Sutcliff, the chairman of the Council for Nautical Archaeology, to a special preview of the Captain Cook exhibition, for members of the Society of Nautical Research. This exhibition which was at the Royal Academy was arranged by the British Museum.

At Bristol I visited the S.S. Great Britain, Brunel's famous steamship which was brought back to Bristol from the Falklin Islands in 1970. The external hull has been repaired and is now sound, it is about half decked and work is now concentrating on restoring the inside of the vessel.

Whilst in London, I discussed with Ray Sutcliff, the chairman of the Council of Nautical Archaeology the implications of the new

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request to retain some of the material for the Western Australian Museum. I am rather concerned that there are a number of people operating in the Indian Ocean, who have rather dubious motives. There now appears to be three rival groups operating or wishing to operate in Mauritius. I feel it may be wise to forward the resolutions of the 2nd S. Hemisphere Conference on Maritime Archaeology and ask the department of Foreign Affairs or (Home ?) Affairs to raise the question with Mauritius Government.

2.5 <u>U.S.A.</u>

Institute of Nautical Archaeology

On arrival in Texas I assisted with the construction of the working model of the Batavia. All the strakes and frames had been cut up according to our original plans. The major frames were then placed on the planking, thus completing the side structure of the ship. The Transom beams were then mounted on the fashion piece, and the two sections were then ready for matching. Working from photographs of the stern section is was possible to determine the angle of the strakes to the fashion piece and the exact location of the strakes as they attach to the fashion piece. The two parts were then attached together and the angle that the side of the ship made with the transom checked by placing a transom lodging knee on the inside of the hull mits correct position. This showed that there were no gross errors in the reconstruction of the stern.

It was immediately obvious that the hull flared out far more than was originally anticipated. Thus the off set from the centre line of the structure, the hull extended 6.7m. laterally at the forward part of the structure. The location of the plane of the true water line was then determined, and the model mounted on a vertical board representing a wall. The model was mounted so that it adopted its true relationship to the horizonal plane. The location of the line of the main gundeck was then determined and this corresponded well with the theoretical waterline and the theoretical position of the deck at the port gunport.

From the position of the 20 Amsterdam foot waterline mark (5.66m) above keel, we now know that the true height of the upper most keel, and the lowest remains would have been about 3m above keel. Thus in side view we have a structure from 3 to 9.46 above keel. Thus it seems unlikely that the structure can be reconstructed in such a way that the keel is on the floor of the building and the upper marks 9.46m above it. The most obvious option is to position the structure so that the gundeck corresponds with the first floor

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is important to retain the symmetry of the ship in the room, canting the structure so that the axis of the hull is not parallel to the walls is to be avoided. Thus the ideal optimum is to mount the transom on the east wall, so that the wall represents the centre line of the ship. This results in the transom projecting 2.75m from wall, and leading edge of structure 10m forward offset from the wall by 6.75m.

A supporting structure was then designed. In the design of this structure it was appreciated that considerations of wall, ceiling and floor strengths have to be taken into account, and that the overall design should be checked by structural engineers. Thus these designs are based on hull considerations, and the strength of the frameworks need to be verified. We have recommended mild steel for the material, as it can be easily worked, is strong and cheap. It should be galvanized and then epoxy coated, as has been done on the Wasa.

The transom supports consist of three brackets, cut to fit onto the stern surface of transoms 1,2 and 3. The stern surface is then bolted into the fashion piece and the transoms, and the side surface extending foreward, bolted through the wall. Gussets are let into the joints to give strength. The wing transom is held by a vertical bracket and bolted to the lower surface of the transom; it again is bolted through the wall. The same arrangement is made for the base of the fashion piece. See Appendix 6 for constructional drawings of these supports. It is possible that a wire support from the roof to the port side of the wing transom will be required. As a result the roof joists will need to be reinforced.

The side of the ship is supported by 'T' shaped frames located at the three saw cuts. The shapes of the frame part of the supports can be obtained from the lofting of the hull. These can be cut out of mild steel plate using oxy-acetelene cutter. The flat part of 'T' will also require a mild curve so that they can adopt the angle of the hull. It is possible to produce full scale tenplates made out of masonite, and have the steel plate cut out in an engineering workshop. However, this has several drawbacks. The shapes will have to be checked against the lofting lines. If we produce the supports, corrections can be made as we go along.

Having cut, and welded the supports, these then must be galvanized, epoxy coated and mounted in place prior to the reassembly. The feet of the supports are made adjustable in offset position by 0.2m, using a bottle screw. A bracket bolted into the floor acts as the support with the adjustment extending outwards to base of support frame. At the level of the gundeck, the support is tied to the wall using a rod with another bottle screw. The upper edge of the support is suspended from a reinforced roof truss. Thus the whole frame work allows several degr[illegible]

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However, before this can be attempted, more information is required. The model 1 has served to sort out the overall concept at the gross level and is therefore only a rough working model. The next phase is to produce a more accurate model, which can serve to solve some of the more detailed problems. Before this can be started it will be necessary to measure all the bevel angles on all of the frames of the ship. This will require extracting all the frames from the conservation tanks and measuring the angles at 10cm intervals along the length of the frames. The strakes will have to be faired to give their original parallel nature, this can be done without extraction from the tanks. The second model, can then serve as a working model to take the lines of the ship. The lines can then be taken off the model and lofted onto the floor of the gallery. The supporting structures can then be prefabricated, from the lines and set up in place. This can be done immediately the second model is finished, and the structures set in place. Thus even though there may be little or no timber ready for the reconstruction, the support frames can be battened, to give the skeletal shape of the hull.

Thus the priorities are as follows from model 1, set up in a reconstruction of the gallery, a decision is required as to how far the stern of the ship should lie back from the south wall and the facade. The upper floor, joists and staunchions should be removed up to the extent of the foreward part of the ship. This can be determined from the decision as to where the stern should be located. The structural engineers should check the strengths and designs of the supporting framework and recommend if the outside east wall requires reinforcing (Appendix 7 gives the weights of the various sections and the recommended supporting system). The frame bevel should be measured as soon as possible and work should start on model 2.

Once the model 2 is completed, and the floor of the gallery concreted, the mould loft can be set up on the floor of the building. I would also recommend that a 1 to 10 reconstruction of the whole ship be attempted. There is enough source material, to make an accurate reconstruction of the missing parts of the ship. We know the ship was 50m long between the sterns which means that the overall length of the model would be about 6m. The model could be made so that it was fully planked on one side, but only skeletal on the other side, so that it could be used for display purposes as well as for research. The model would have to be constructed in its final location (possibly on the ground floor in the S.W. or S.E. corner of the gallery) because of its weight.

It is therefore an urgent priority to set up working facilities in the new gallery. The workshop will have to be located in the gallery, where model 2 will be constructed. This will require a large woodworking bench and a band saw with a tilting table. Two large

onto the floor of the gallery. The supporting structures can then be prefabricated, from the lines and set up in place. This can be done immediately the second model is finished, and the structures set in place. Thus even though there may be little or no timber ready for the reconstruction, the support frames can be battened, to give the skeletal shape of the hull.

Thus the priorities are as follows from model 1, set up in a reconstruction of the gallery, a decision is required as to how far the stern of the ship should lie back from the south wall and the facade. The upper floor, joists and staunchions should be removed up to the extent of the foreward part of the ship. This can be determined from the decision as to where the stern should be located. The structural engineers should check the strengths and designs of the supporting framework and recommend if the outside east wall requires reinforcing (Appendix 7 gives the weights of the various sections and the recommended supporting system). The frame bevel should be measured as soon as possible and work should start on model 2

Once the initial facilities have been established in the gallery, and the bevel angles measured, I estimate it will take a month of uninterupted work to complete model 2, and a further two months to construct the framework. It would then be possible to start work on the model of the complete ship which would take about 6 months to complete. It should be possible therefore that the general public could see the completed framework showing the overall proportions of the ship, together with some of the already treated timer in situ by September. The only real limit to this time schedule is the availability of facilities in the gallery, the engineers report, and access of the frames in conservation. There is a possibility that when the reconstruction is finished, it will be possible to do a certain ammount of reconstruction work. The general outline of this is shown in Figs. 3, 4, 5 and 6 in Appendix 4.6. Essentially, the lower floor access will be into a completely sealed off internal hold, (below the gundeck). It may be possible to mock up part of the powder room, shot locker complex. The area would not be a through way, and the ground floor plan is shown in fig. 5 Appendix 4.6. The gundeck is shown with two mock up guns in the two gun ports. See fig. 3 and fig. 6, Appendix 4.6. The plan shows the deck open, but it may be better to roof it over with a modern ceiling reconstructed along lines of original. This will give more feeling for the enclosed nature of the gundeck. The gallery on the first floor may have to be rethought, since there will be no stair access from the 1st floor to the ground, now that the ship sits against the wall.

During my stay at Texas A and M University I have been greatly assisted by Mr. Paul Hunley, a research assistant at the Institute of Nautical Archaeology. Mr. Hunley has been responsible for the construction of model 1, and he and Mr. Dick Steffy have provided the ideas and suggestions that are the basis of this section of the report. Mr. Hunley has expressed an interest in working on this project in the future and I would suggest that, if funds are available, we should offer him a contract initially for six months starting at Christmas 1979 and renewable for a further year as Graduate Assistant or Assistant Curator.

I am convinced that his presence would greatly facilitate an efficient reconstruction of the ship. I would also like to thank Dr. George Bass, Mr. R. Steffy, Mr. P. Hunley and the staff of the Institute of Nautical Archaeology for making my stay so pleasant and rewarding.

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Appendix 4.1

The Koh Kradat Wrecksite, a Preliminary Report

Jeremy Green
Department of Maritime Archaeology
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Western Australian

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Western Australian Museum
Fremantle
Western Australian

Introduction

In January 1979 the author was invited by Dr. Pensak Howitz, of Silpakorn University, Bangkok, to conduct a three week course on maritime archaeology at Silpakorn University as part of the S.P.A.F.A. programme (see S.P.A.F.A., 1976). As part of this course, two weeks were devoted to a field excavation project. A shallow water wrecksite was selected for excavation by Dr. Pensak near the island of Ko Kradat, in the SE of Thailand, in the province of Trat.

Ko Kradat is a small island (see fig. 1) about 2.5 km long and 60 m high. The island has a coconut plantation which is worked by about half a dozen families, the sole island population. Boardering the island, is a coral fringing reef about 500 km wide. The edge of this living coral reef drops off to about 10 m, to a flat featureless seabed. The wreck site lies in about 2.5 m of water at high water, (the tidal range being about 1 m) about 1 km N of the northern end of the island. The site consisted of a mound of black-granite like river washed ballast stones, approximately 16 m in diameter and 0.5 m high. Scattered around the ballast and in the area surrounding the site, up to about 50 m away, were shards of large stoneware jars. The site has been the subject of a previous excavation in 1977, (see Pensak, 1977), and remains of two (?) previous excavation areas were noted.

The Excavation

A 40 m base line was laid across the site, along the NE side of the ballast mound. A simple trilateration survey of the ballast mound was made, using two tapes based on two fixed points on the base line. This plan (fig. 2) which gave a rough outline of the site, was complimented by a second survey using a 2 m grid square with one side laid against the base line. By sighting along the side at 90° to the base line, it was possible to set a tape measure at right angles to the base line, across the wreck site. The ballast mound and old excavation features were then measured on the tape. This process was repeated at 2 m intervals across the site, and the details plotted on the site plan.

It was decided to excavate a trench across the wreck site. A pair of lines, 2 m apart, were set across the site, at right angles to the base line, at the 18 and 20 m marks. This served to delineate the edge of the excavation trench

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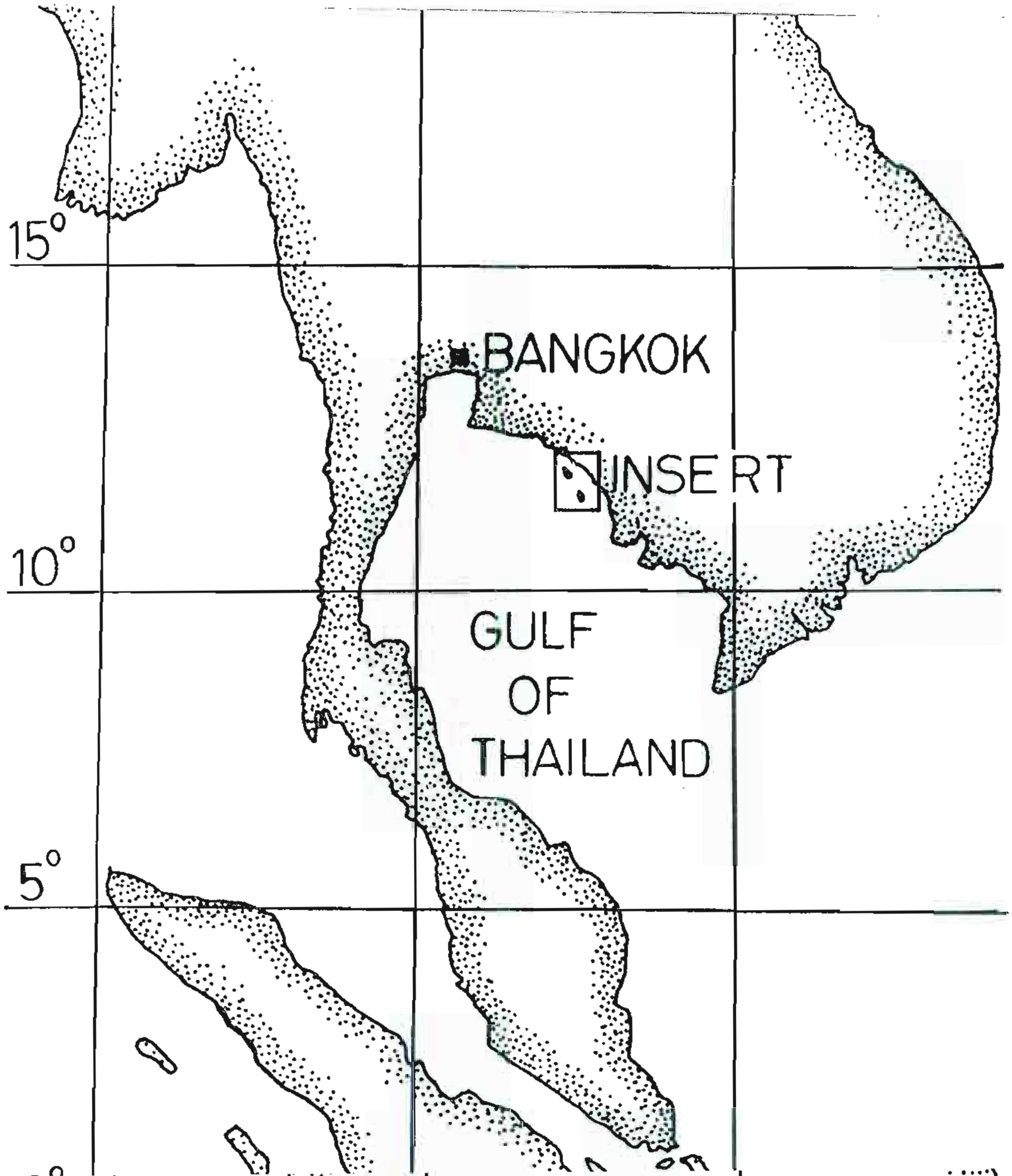
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BANGKOK
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10°
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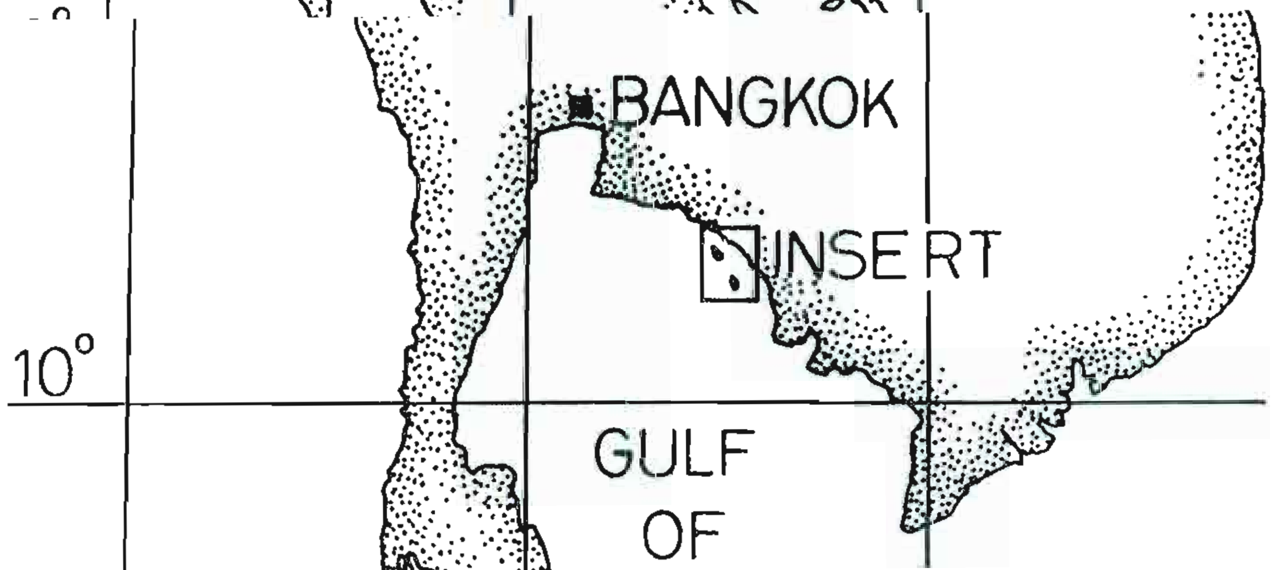
OF
THAILAND
5°


BANGKOK
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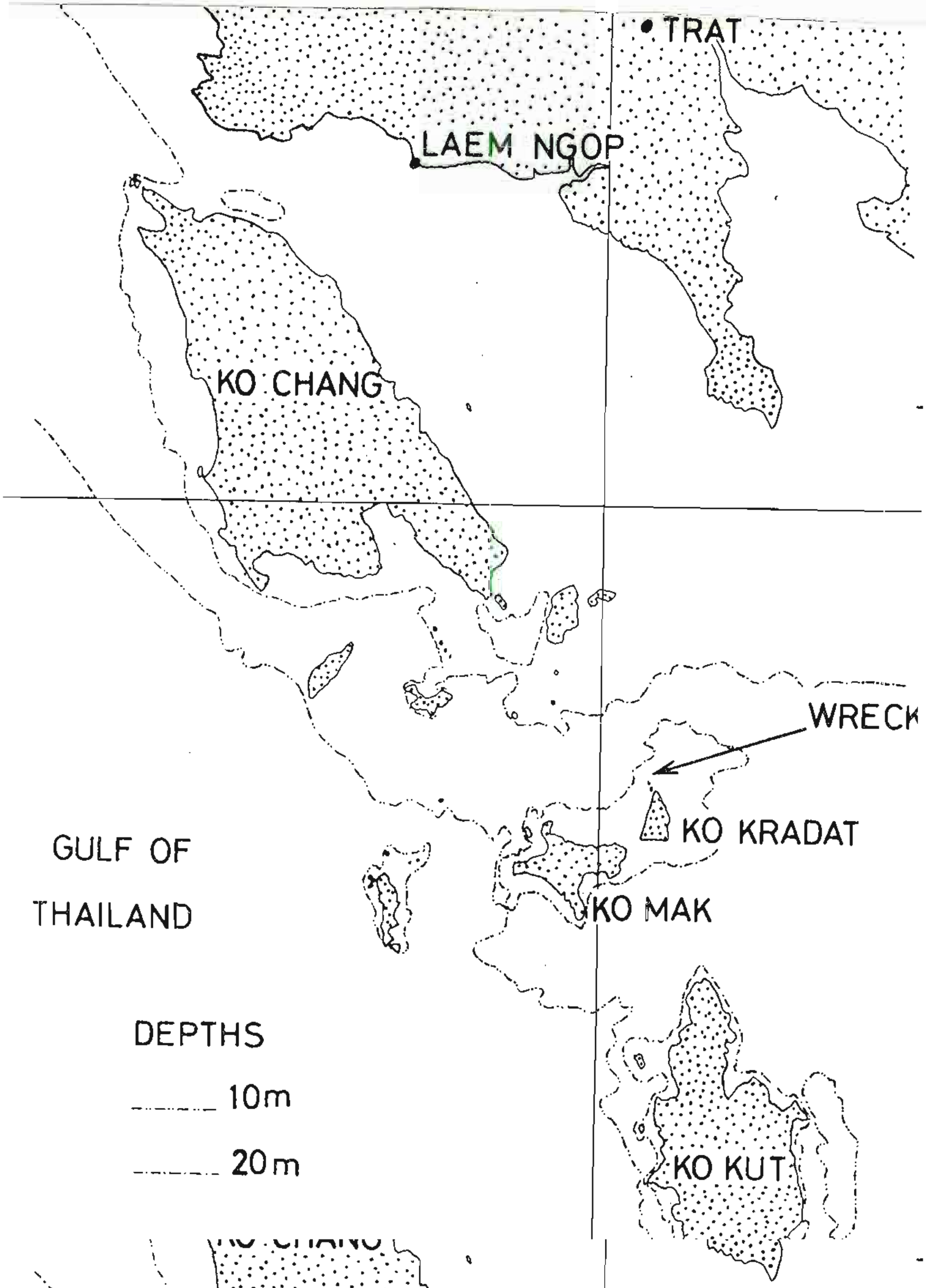
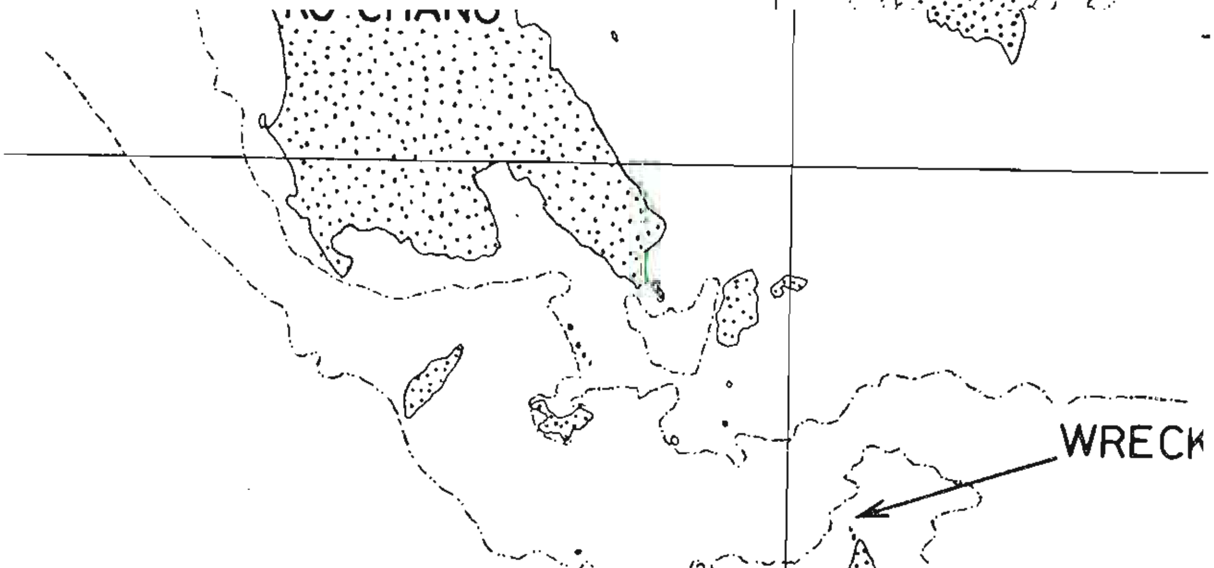
OF


TRAT
LAEM NGOP
KO CHANG
WRECK
KO KRADAT
GULF OF
THAILAND
KO MAK
DEPTHS
10m
20m
KO KUT


WRECK

Thus two grid squares were worked at one time, two students to each square. The first squares (1 and 2 in fig. 2) were started at opposite sides of the ballast mound.

The first operation was to remove the ballast stones. These were counted and moved to spoil dumps well off the wreck site. Then the large coarse stoneware shards were collected in a basket, and smaller coral lumps removed from the surface. Since there were no excavation equipment available such as water dredge, the light sand was then hand fanned out of the grid square. This uncovered the fine stoneware shards and complete objects. Once the first grid squares were completed, the following squares were excavated by back filling the ballast and spoil into the previously excavated grid squares.

The material raised was divided into three groups: coarse stoneware shards; fine stoneware and earthenware shards; and complete fine stonewares.

The coarse ware was mainly large storage jars, about 0.75 m high, with flat bases and usually four looped handles with an example of an oven (?) and a type of base with four feet. The fine wares, consisted of cover bowls, jars, jarlets, earthenware pots with inscribed decoration and blue and white Chinese porcelain. The cover bowls represented a number of types, bases had either a rimmed foot or a flat base. The lids consisted of three types: plain lids; lids with lotus bud handles; and lids with "mangosteen" decoration. The jars consisted of types with small eared handles, vertical shoulder handles, small jars with no handles, and pear - shaped vases with slightly flaring mouth. In most cases this material was a yellowish buff, fine stoneware, with a black or bluish-black brush stroke underglaze decoration. There were also some examples of Chinese blue and white porcelain, with Chinese characters on the base. About 25 complete items were recovered with many thousands of stoneware shards.

During the final phase of the excavation, 100 ballast stones were collected randomly from the trench, each stone was weighed.

The average weight of the stones was 3.5 kg with a variation of ± 2.4 kg. The number of stones collected from each square are tabulated in Table 1.

GRID SQUARE	1	3	5	6	4	2	8
NUMBER OF STONES	223	224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

This uncovered the fine stoneware shards and complete objects. Once the first grid squares were completed, the following squares were excavated by back filling the ballast and spoil into the previously excavated grid squares.

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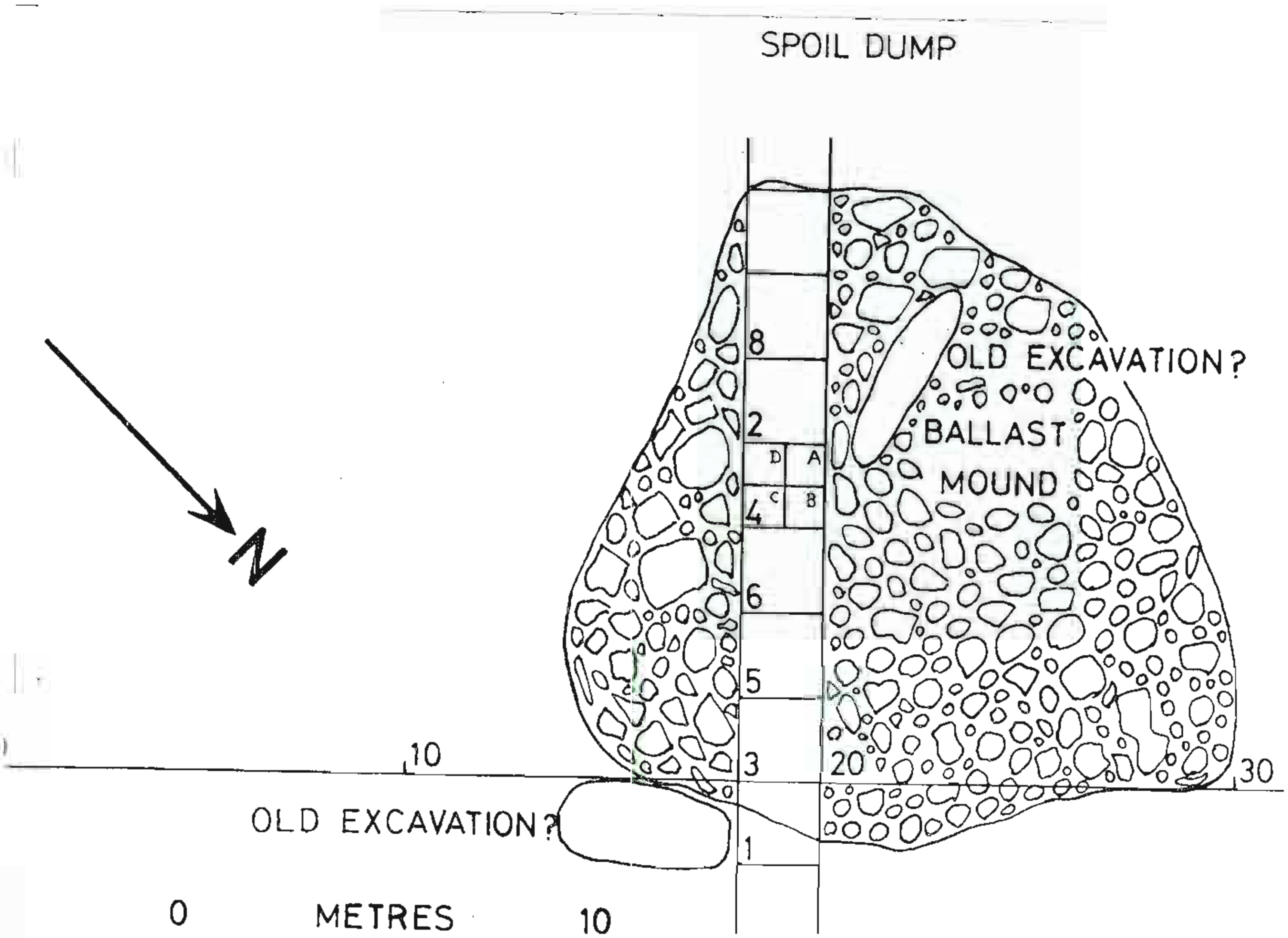
SPOIL DUMP
OLD EXCAVATION?
BALLAST
MOUND
N
8
2
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A
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4
6
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20
30
OLD EXCAVATION?
1
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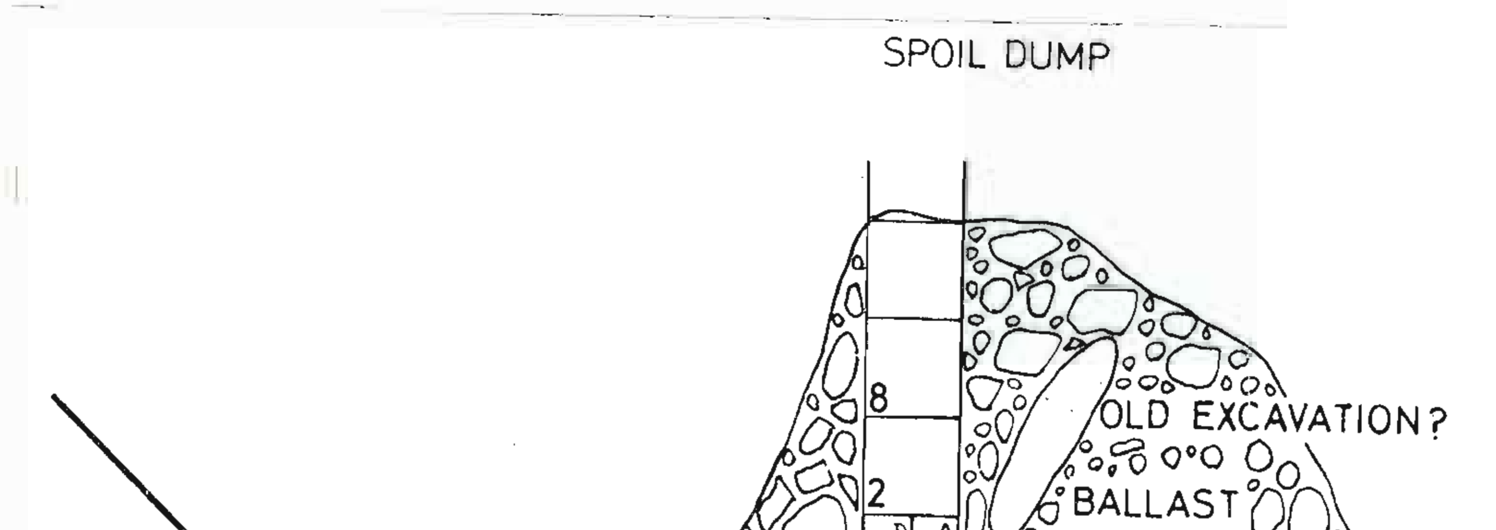
METRES
10


SPOIL DUMP
8
OLD EXCAVATION?
2
BALLAST

The total number of stones removed from the grid squares was 1578, multiplying this by the average weight gave an average of 5.5 tonnes in the grid squares. Since the average number of stones per grid square was 225 or 56 per square metre, the approximate weight of stones on the whole site, (assuming that this density is representative) is 35 tonnes (180 area of site x 56 x 3.5).

Conclusions

Only a small proportion of this site was excavated, (a total of 24 m^2), nevertheless a large amount of ceramic material was recovered. The fine ceramics lay almost exclusively below the ballast mound, whereas the coarse ware appeared more superficial and also widely scattered, in some cases a long way from the site.

There appears to be a considerable difference in the materials recovered in 1977 and 1979. This possibly reflects a different artifact composition in the 1977 excavation area. Unfortunately as no site plan has been published, the only information is that the excavation area was at the north of the site.

Thus the differences are as follows:-

Present 1977 but not found 1979.

1. Wooden planking and pegs, (some small unassociated fragments were found in 1979, but not of any real significance).
2. Sugar palm pots (two)
3. Basin (one)
4. Vase with flared neck (one)
5. Vase pear - shaped with flared neck (one)
6. Large monochrome storage jars (two).
7. Bowl with everted rim (one).

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Thus the differences are as follows:-

Present 1977 but not found 1979.

Common 1979 and 1977.

1. Cover bowl with foot rim. Refuge (1976), Klasse 2.

2. Cover bowl with lotus-bud handle.

3. Cover bowl with mangosteen handle.

Present 1979 but not 1977.

1. Small jarlets (three). Refuge (1976), Afb. 135.

2. Jars with shoulder handles (three). Refuge (1976), Afb. 169.

3. Vase with smoothly flaring neck (two). Refuge (1976) Afb. 109.

4. Jar with eared handles (two). Refuge (1976), Afb. 165.

5. Coarse ware oven (one).

6. Coarse ware stand (one).

7. Cover bowl base with no foot rim. Refuge (1976), Klasse 1.

8. Cover bowl lid with no handle.

This indicates that there may well be a significant distributuion of material on this site and further excavation is definitely warranted. This author considers that the granite stone is almost certainly ballast, and certainly not, as Dr. Pensak has suggested, possibly a main cargo. It could have been paying ballast, but this seems unlikely.

Thus the excavation has shown, that the ship grounded on the northern end of the island of Ko Kradat. Much of the smaller cargo items of ceramic were trapped under the ballast. The evidence indicates that there may well be a cargo distribution pattern on the site.

Acknowledgements

I would like to firstly thank Dr. Pensak Howitz, for inviting me to do this work, and for her hospitality and the hospitality of the Royal Danish Embassy in Bangkok. I would like to thank the Royal
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The Survey Procedure on Santa Antonio de Tanna, Second Season.

Appendix 4.2

The Survey Procedure on Santa Antonio de'Tanna, Second Season.

This section of the report deals with the surveying techniques used to record the structure of the ship uncovered during the second season. The techniques were based on the experience of the first season and were devised to meet the rather unique conditions of the site.

Since it was required to produce detailed plans of a three dimensional shape, both photogrammetry and standard measurement recordings were used. However, the nature of the site produced limitations in the applications of both techniques. Poor visibility, except at Spring high tides, precluded the constant use of photographic recording. Likewise, poor visibility and tidal currents,made tape measurements unreliable and it was difficult to establish an acurate base line for recording purposes. Additionally, problems were encountered due to the peculiar orientation of the ship, which lay on a steep slope, inclined 20° down towards the bow and with a tilt of 54° to port.

The keelson was twisted along its exposed length, and there was evidence at the scarf joint that the stern section, including the keelson, had moved in relationship to the bow.

These distortions have been extremely difficult to sort out because of the unusual orientation and the lack of a useful datum, such as the base of the keel to work from.

The overall shape of the structure was recorded by measuring profiles across the hull of the ship at right angles to the keelson at 1m intervals. A stereo photogrammetric survey over the whole of the inside of the ship was made so that detailed information could be recorded of the internal structure. Control points were surveyed so that the photogrammetric survey could be related to the profiles and incorporated in the overall plans. Detailed measurements were also made of the keelson, which served as the base-line for the survey.

Profile Recording

The profiles were measured at one metre intervals along the keelson using a circular 0.75m diameter, 360° protractor, graduated in half degrees and mounted on a bar 1m long. The bar was clamped on the upper (starboard) side of the keelson so that the plane of the protractor was at right angles to the keelson. A pin mounted at the

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reading to be taken, he gave two pulls on the tape and the protractor operator noted the readings and gave a similar signal when he was finished.

Using this technique it was possible to work in poor visibility (circu. 1m) where the two operators were out of sight of each other. The double distance measurement helped to sort out errors and missed readings. A variety of techniques were used to ensure that the tape operator took the readings in a line at right angles to the keelson. One of the quickest and simplest (and therefore the best) was to scribe a line on the timbers, using a one metre square placed against the keelson. The line was extended across the site using a straight edge. The overall method was fast and reasonably accurate.

In a 61 minute dive, with experience, it was possible to do two 6m profiles consisting of a total of 80 readings. Using a small hand-calculator (Hewlett Packard 25) the polar co-ordinates were converted to rectangular (or x and y) co-ordinates, which greatly facilitated the plotting of data. The calculations required 0.5m to be added to the measured distance (to allow for string stirrup) and, and, provided the angles were recorded consistantly, the results when converted to rectangular co-ordinates were plotted on graph paper. The accuracy of the technique was basically limited by the size of the protractor and was about ± 2%.

Photographic Recording

Two Nikonos III cameras were mounted 0.5m apart on an aluminium stereo bar. One camera was firmly mounted in a locating bed of hard epoxy resin, whilst the other was mounted in a flexible bed of silicon rubber and was provided with screws to adjust the vertical and horizontal tilt of the camera. On hand, two targets with viewing holes through their centres were mounted 0.5m apart on a levelled bar at about 5m from the levelled stereo bar. Using plane mirrors in place of the lenses, the stereo bar was adjusted so that the image of the target in the morror, on the fixed camera, when viewed through the corresponding target, coincided with the centre of the optical axis of the fixed camera. Subsequently, the adjustable camera was adjusted so that it's corresponding target coincided with the optical axis. In this way both cameras were accurately aligned so that their optical axies were parallel. The stereo bar was then mounted on the photo-tower to be used underwater, this tower consisted of a 2m square base graduated in 0.1m intervals, with stays supporting a 2m bar, 1.88m vertically above the base. The bar was constructed so that, when the stereo bar was fitted to it

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Photographic Recording

the ratio of the length at this line to the effective focal length of the photograph gives the tangent of the angle of the true vertical to the camera axis. Photographic exposures were made at 1m intervals, thus ensuring good end-and on the keelson to the rod were measured using a carpenter's level. With this information, it was possible to calculate the three dimensional co-ordinates of all the control points.

Conclusions

This report essentially deals with the recording techniques. It is hoped to complete the recording of the fore part of the ship during the next season and publish the results subsequently. However, as the author is at present working on this material, some comment on the results is included. Results indicate that the photogrammetric technique gives the greatest information and flexibility. Thus, at a low level of accuracy, with little effort, a photomosaic of the whole site, using one of the stereo-pairs, has been made. This gives good visual information, but suffers from distortions caused by forcing a three dimensional curved surface into a two dimensional plane. With a simple parallax bar and mirror stereoscope, spot heights can be determined and profiles made. With a radial plotter, orthographic plans of the stereo-pairs can be made, but preliminary results have not been encouraging. A programme using a stereotope and other stereoscopic plotting instruments is being carried out to determine the most effective method of producing plans. Using the orientation of the true vertical for each stereopair, each plan may be reduced to common vertical and horizontal planes.

True profile data has shown that at large distances the errors create problems in plotting the vertical and horizontal plans. The recording system will be modified for the next season to give greater accuracy. Also the trilateration system has similar problems related to accuracy. A small computor programme is being constructed for use with a hand calculator to give greater accuracy.

The results of this work so far, show that the area of underwater surveying has some extremely complex problems. Little has been published on this type of work, which is surprising, considering its importance. Some form of compromise exists between accuracy and time, possible the use of photography and hand measurement is the answer. It is hoped that this work may resolve this problem.

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Appendix 4.3

Maritime Archaeological Applications for a Programmable Calculator

by

Jeremy Green

Head Department Maritime Archaeology

W.A. Museum

by

Jeremy Green

Head Department Maritime Archaeology

W.A. Museum

The recent advances in microprocessor technclogy has lead to the development of the programmable calculator or computor. This instrument has a number of applications in the field of maritime archaeology.

The type of instrument referred to in this article is essentially an advanced programmable calculator, in which data and programme storage can be recorded and read on magnetic cards. A number of instruments are available on the market, of varying levels of sophistication.

The type used by this author was the Texas Instruments TI 59 with a PC 100A Thermal Printer. This machine has the capability range from up to 100 data registers and 160 programme locations or steps, down to 960 programme steps and no data registers. These memory stores (data registers and programme steps) can be recorded on two magnetic cards, and stored permanently for future use.

The advantage of this type of instrument is that it is compact, relatively cheap, simple to operate and yet capable of doing long, complex calculations.

Thus, although it is possible to do any of the following calculations with an ordinary calculator with no memory, the sheer length of time the calculations take, and the drudgery that goes with it, has resulted in non - mathematical or graphical approaches to solve these problems.

With this instrument, it is feasible for an archaeologist, with a limited mathematical background, and no knowledge of computor language, to learn to operate it in a day or so. Indeed, if the programme was written for him, and recorded on magnetic cards, all he would need to do would be to read the cards into the machine, enter the relevant data, and press the required buttons to obtain his results. The additional advantage is that data can be processed and analysed in the field. This is a great improvement over large computor where the data has to be sent away to a computor centre, usually at the end of a field season. The processing of data on site, gives immediate feed back to the archaeologist, allows for corrections in misrecorded data, and provides immediate field informati

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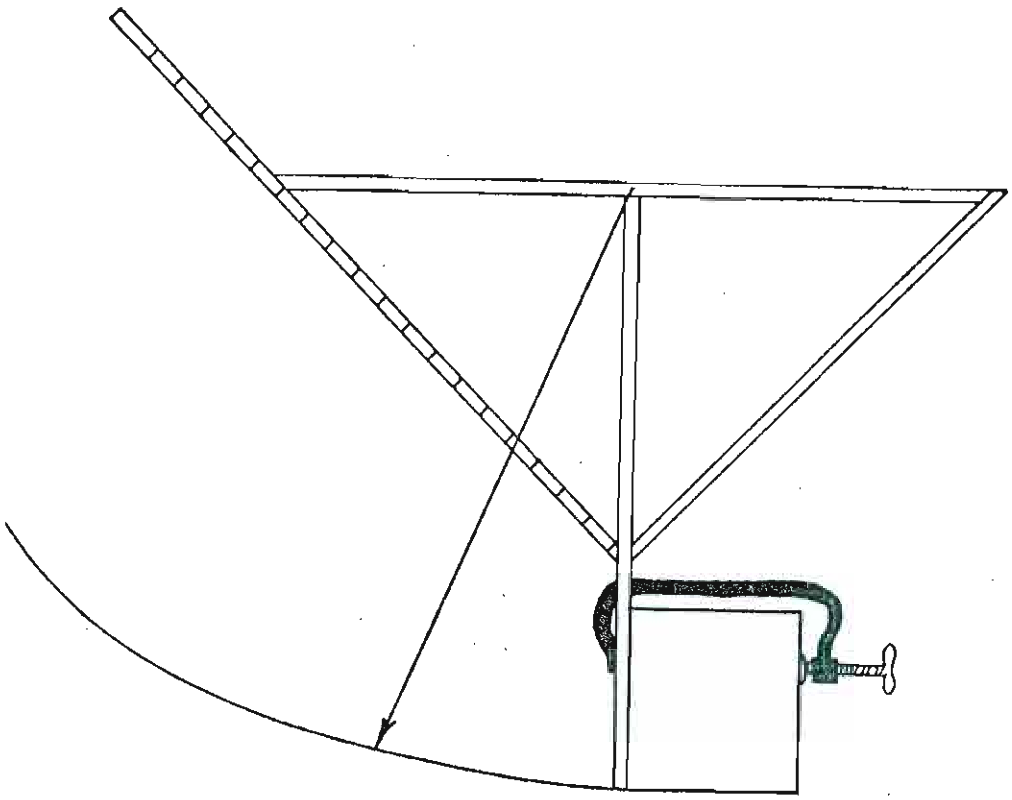

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D=.30 (23-25)

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1.57
3.585) 2
1.48
3.335) 3
1.475
3.08) 4
1.365
2.9) 5
1.285
2.985) 6
1.225
2.82) 7
1.185
2.61) 8
1.15
2.35) 9
1.08
2.185) 10
1.05
2.225) 11
1.07
2.045) 12
0.97
1.51) 13
0.91
1.31) 14
0.825
1.06) 15
0.745
0.77) 16
0.695
0.86) 17
0.625
0.68) 18

1.57
3.585) 2
1.48
3.335) 3
1.475
3.08) 4
1.365
2.9) 5
1.285
2.985) 6
1.225
2.82) 7
1.185
2.61) 8
1.15
2.35) 9
1.08

#10

D=.68 (1-22)

1.635
3.55
✓ 3.854194514 Y
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1.57
3.585
✓ 3.920513045 Y
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1.48
3.335
✓ 3.738398477 Y
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1.475
3.08
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1.365
2.9
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✓ 3.515351544 Y
1.036594678 6 X
1.225
2.82
✓ 3.388307951 Y
.8771369503 7 X
1.185
2.61
✓ 3.204285021 Y
0.746094837 8 X
1.15
2.35
✓ 2.966163152 Y
.6186890643 9 X
1.08
2.185
✓ 2.831044669 Y
.4397852675 10 X
1.05

1.679226746 2 X
1.48
3.335
✓ 3.738398477 Y
1.464445912 3 X
1.475
3.08
✓ 3.50353408 Y
1.364862245 4 X
1.365
2.9
✓ 3.391550124 Y
1.14620581 5 X
1.285
2.985
✓ 3.515351544 6 Y

interior profiles of the cross sections of the hull. The profiles were initially recorded with a simple protractor and tape measure system. (See Green, 1978).

Rather than plotting the data using a protractor and ruler, a simple programme was written to convert, what were essentially polar co-ordinates into rectangular X and Y co-ordinates. The results could then be plotted far more quickly and accurately on graph paper, with an allowance written into the programme for the length of string to be added to the taped distance. It became obvious however, that the size of the protractor used was too small in relation to the maximum distances involved, (circa. 5m). Since the angle could only be measured to ± 0.25°, the limit of accuracy was related to this variable, rather than the distance measurement, ± 0.005 m.

The recording system was therefore modified during the second season, to give greater accuracy in the measurement of the angle. A rigid triangular framework was used (fig. 1), and the angle measurement was made by noting the intersection at the string - tape on the hypotenuse of the frame. In this case, a more sophisticated programme was used. The data was entered in the machine in a programme which stored each angle and distance measurement in a memory store series, and printed the data as a list, (fig. 2). Thus the raw data, on mylar sheet direct from the wreck site was entered in the calculator, and the print - out used as a fair copy, and glued into the record book. Finally, the data was recorded on magnetic cards and stored as an additional record. The processing of this data used a 62 step programme utilising a library programme to solve the triangle for which one side and one angle are fixed and known, and the third side is the recorded variable. Thus the triangle can be solved, and the required angle calculated; the polar co-ordinates can then be converted to rectangular and printed out on the printer. This calculation for up to a maximum of 50 points (100 data units) takes about 10 minutes to get the print out.

The data is listed under X and Y co-ordinates (fig. 3) and can then be used to plot the profile. These calculations could be solved graphically, however, this programme greatly speeds the operation, and presents the data in easily plotted rectangular co-ordinates.

2. Three Dimensional Trilateration

The simple trilateration in two dimensions will be familiar

with an allowance written into the programme for the length of string to be added to the taped distance. It became obvious however, that the size of the protractor used was too small in relation to the maximum distances involved, (circa. 5m). Since the angle could only be measured to ± 0.25°, the limit of accuracy was related to this variable, rather than the distance measurement, ± 0.005 m.

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in the photogrammetric recording of the hull were required. The control points consisted of three series of points: along the port side of the ship; along the keelson; and along the starboard side. The points in each series were separated longitudinally by one metre. It was required to know the co-ordinates of these points in relationship to the X, Y and Z axes of the ship. (X axis being the longitudinal axis of the ship, the Y axis the lateral and the Z the vertical).

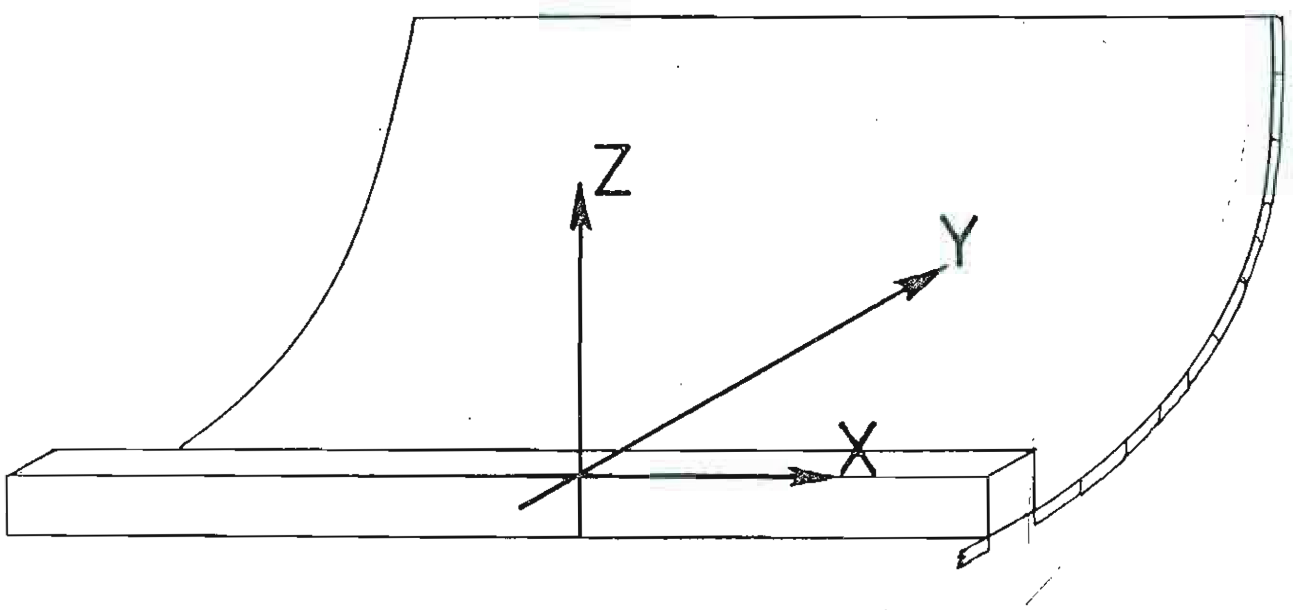
Initially one might have considered using a bubble tube to determine the heights of Z co-ordinates of the points, but since the main axes of the ship make large angles with the true horizontal plane, a complex co-ordinate transform programme would be required; the bubble tube, measuring true vertical distances is indirectly related to the co-ordinate framework. Instead, as an experiment, the co-ordinates were determined by measuring the distances from three fixed points.

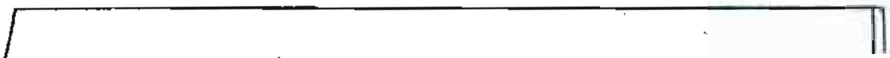
To simplify the calculation, the three fixed points were at the same distance apart, one forming the origin of a Cartesian co-ordinate system, and the other two lying on the X and Z axes, fig. 4. The practical situation consisted of a bar - taught line, stretched from one end of the keelson to the other. A flat iron bar was clamped to the starboard side of the keelson, to form Z axis. The perpendicular distance from the line to the bar was measured, and then set up two metres further up the bar, to give the 2 m position on the Z axis, fig. 5. Assuming that the bar is clamped at the 10 m central point on the keelson, measurements were then taken from the origin (string) and the Z = 2 m points, to the port and starboard control points corresponding to 8 m 10 m and 12 m fig. 6. If this procedure was repeated every two metres along the keelson, enough information was recorded to enable a statistical average of each point to be made. The mathematics of the situation was quite simple. The three reference points: the origin A = (000); the 2 m point on the X axis B = (200); and the 2 m point on the Z axis A_1 (002), for example, are the points from which three distances to a point P are measured AP, BP and A_1P. Applying the cosine formula to triangle APB, it is possible to determine angle PAB. The X co-ordinate of P is thus AP CosPAB. Similarly for triangle APA_1, angle PAA_1 can be determined, giving the Z co-ordinate of P as AP Cos PAA_1. The Y co-ordinate is thus $\sqrt{AP^2 - X^2 - Z^2}$.

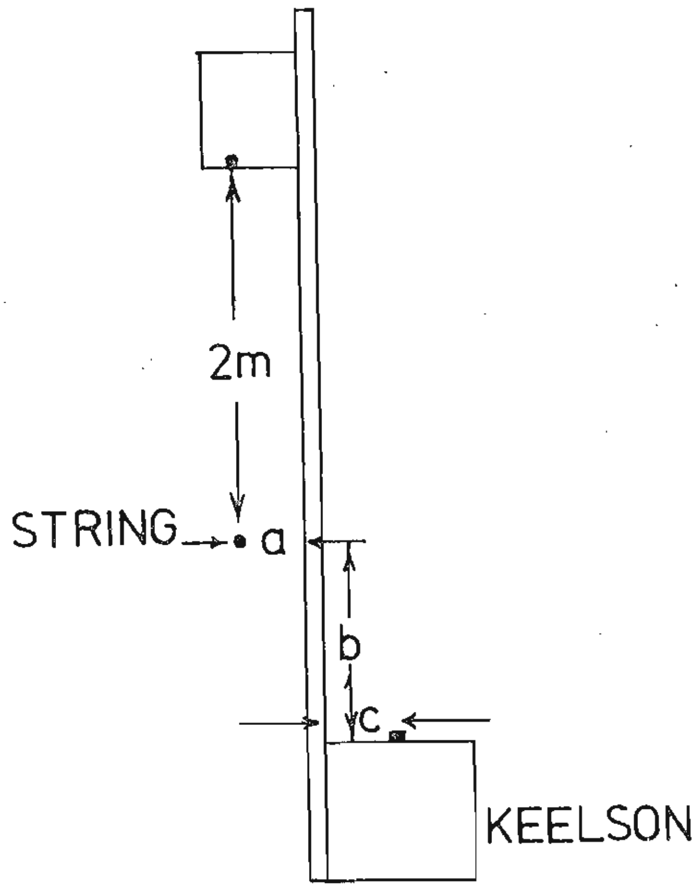
This process can be repeated

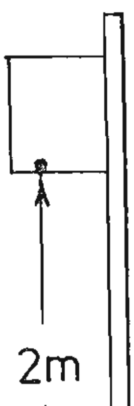
Initially one might have considered using a bubble tube to determine the heights of Z co-ordinates of the points, but since the main axes of the ship make large angles with the true horizontal plane, a complex co-ordinate transform programme would be required; the bubble tube, measuring true vertical distances is indirectly related to the co-ordinate framework. Instead, as an experiment, the co-ordinates were determined by measuring the distances from three fixed points.

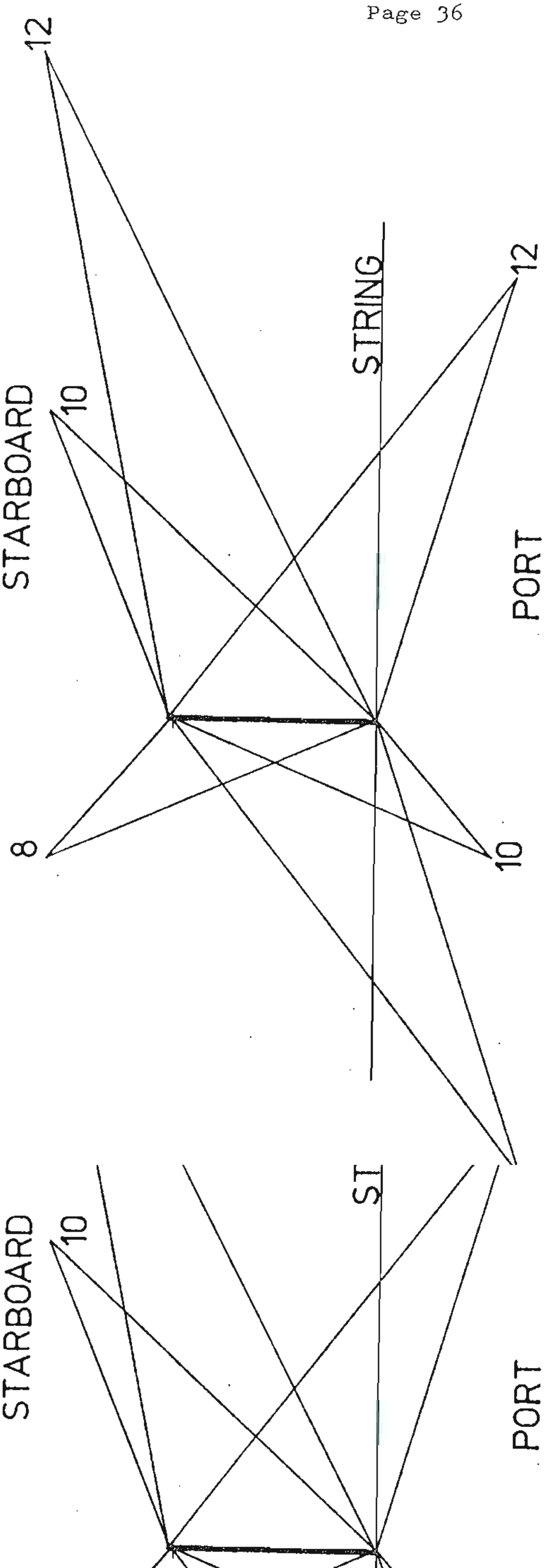
To simplify the calculation, the three fixed points were at the same distance apart, one forming the origin of a Cartesian co-ordinate system, and the other two lying on the X and Z axes, fig. 4. The practical situation consisted of a bar - taught line, stretched from one end of the keelson to the other. A flat iron bar was clamped to the starboard side of the keelson, to form Z axis. The perpendicular distance from the line to the bar was measured, and then set up two metres further up the bar, to give the 2 m


Z
Y
X




2m
STRING
a
b
c
KEELSON


2m



12
STARBOARD
10
STRING
12
PORT
8
10
STARBOARD
10
ST
PORT

the principal that, the sides of a square in an oblique photograph appear, when projected, to meet at an artificial horizon, as the result of the perspective effect, fig. 7. Thus for example, in a photograph of parallel railway lines, they meet and vanish at the horizon. If the parallel sides of a square in an oblique photograph are projected to their vanishing points, the two points, so formed lie on the horizon. Thus the horizon line can be constructed. The perpendicular from the principal point of the photograph, to this horizon, gives the azimuth of tilt of the camera and the distance from the principal point to the horizon line, is proportional to the angle of tilt.

In order to determine the azimuth and angle of tilt, the eight co-ordinates of corners of the square are measured using the principal point as the origin, and the sides of the photograph as the X and Y axis.

The co-ordinates of the four points 1, 2, 3, 4 are: X_1, Y_1; X_2, Y_2; X_3, Y_3; X_4, Y_4.

The four equations for the straight lines joining these points are:

$$Y = m_1X + k_1 \quad \text{where} \quad m_1 = \frac{Y_1 - Y_2}{X_1 - X_2} \quad \text{and} \quad k_1 = \frac{X_1Y_2 - X_2Y_1}{X_1 - X_2}$$

$$Y = m_2X + k_2 \quad \text{where} \quad m_2 = \frac{Y_4 - Y_3}{X_4 - X_3} \quad \text{and} \quad k_2 = \frac{X_4Y_3 - X_3Y_4}{X_4 - X_3}$$

$$Y = m_3X + k_3 \quad \text{where} \quad m_3 = \frac{Y_3 - Y_2}{X_3 - X_2} \quad \text{and} \quad k_3 = \frac{X_3Y_2 - X_2Y_3}{X_3 - X_2}$$

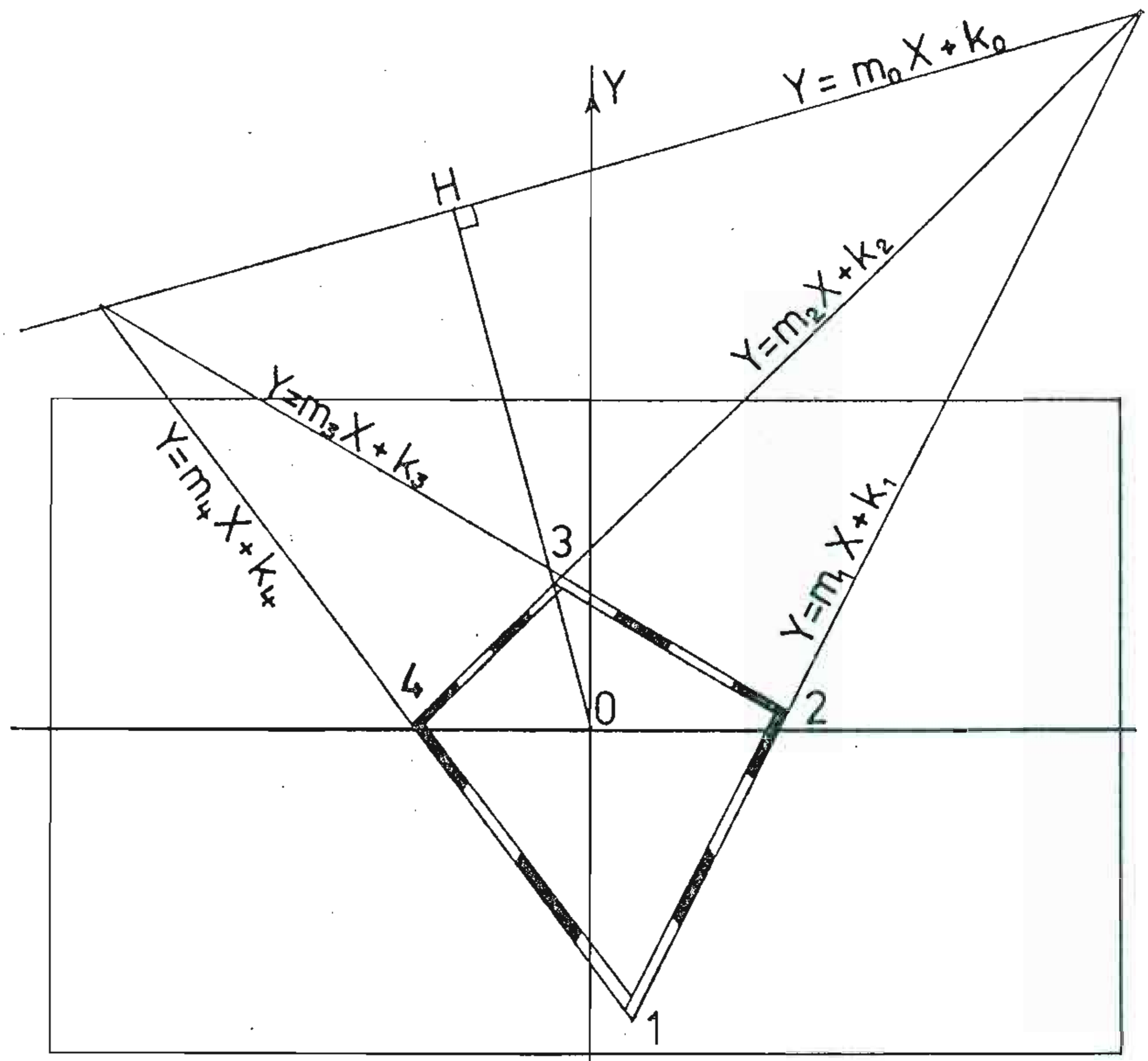
$$Y = m_4X + k_4 \quad \text{where} \quad m_4 = \frac{Y_4 - Y_1}{X_4 - X_1} \quad \text{and} \quad k_4 = \frac{X_4Y_1 - X_1Y_4}{X_4 - X_1}$$

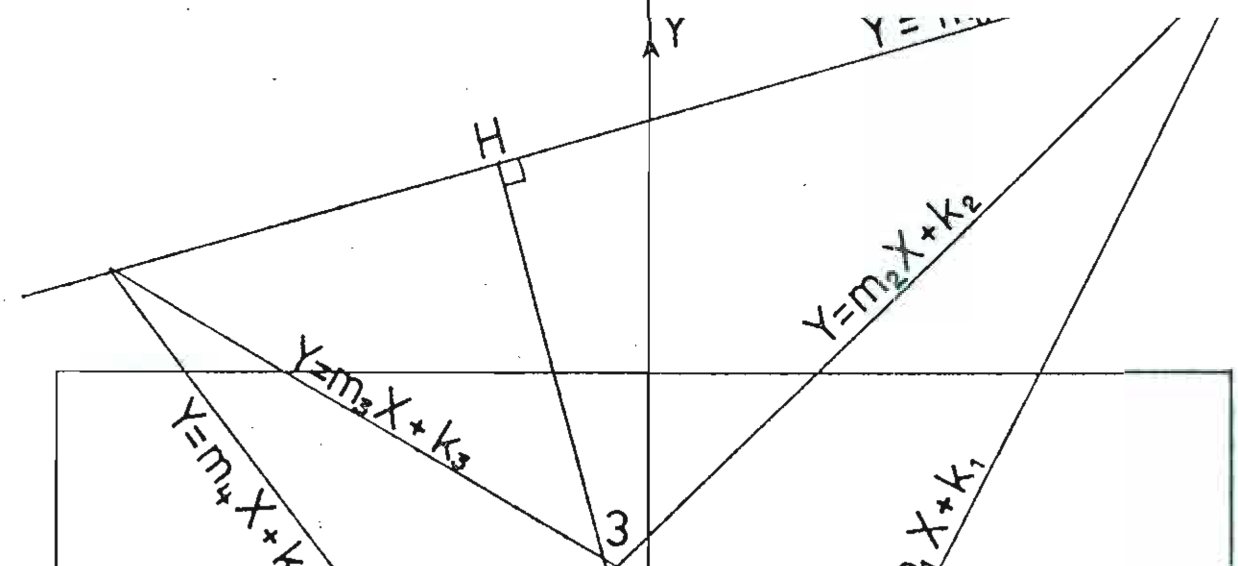
In order to determine the azimuth and angle of tilt, the eight co-ordinates of corners of the square are measured using the principal point as the origin, and the sides of the photograph as the X and Y axis.

The co-ordinates of the four points 1, 2, 3, 4 are: X_1, Y_1; X_2, Y_2; X_3, Y_3; X_4, Y_4.

The four equations for the straight lines joining these points are:

$$Y = m_1X + k_1 \quad \text{where} \quad m_1 = \frac{Y_1 - Y_2}{X_1 - X_2} \quad \text{and} \quad k_1 = \frac{X_1Y_2 - X_2Y_1}{X_1 - X_2}$$


Y
Y = m0X + k0
H
Y=m2X+k2
Y=m3X+k3
Y=m4X+k4
Y=m1X+k1
3
4
0
2
1


Y
H
Y=m2X+k2
Y=m3X+k3
3

The co-ordinates of the vanishing points are: X_{01}, Y_{01}; and X_{02}, Y_{02} and are given by:

$$X_{01} = \frac{k_2 - k_1}{m_1 - m_2} \qquad Y_{01} = m_1 X_{01} + k_1$$

$$X_{02} = \frac{k_4 - k_3}{m_3 - m_4} \qquad Y_{02} = m_4 X_{02} + k_4$$

The equation of the line formed by these two points, the horizon line is:

$$Y = m_0 X + k_0 \text{ where } m_0 = \frac{Y_{01} - Y_{02}}{X_{01} - X_{02}} \text{ and } k_0 = \frac{X_{01} Y_{02} - X_{02} Y_{01}}{X_{01} - X_{02}}$$

The perpendicular to the horizon line from the origin, meets the horizon line at co-ordinate: X_h; Y_h. This is the azimuth

$$\text{where } X_h = \frac{-m_0 k_0}{m_0^2 + 1} \qquad \text{and } Y_h = \frac{k_0}{m_0^2 + 1}$$

The azimuth $A = \text{Tan}^{-1} \frac{-1}{m_0}$ measured in the normal convention,

anticlockwise from the X axis. The angle of tilt $\emptyset$ is the angle made by the principal axis of the camera and the perpendicular from the optical centre of the camera to the grid square fig. 8, and is given by:

$$\emptyset = \text{Tan}^{-1} \frac{F}{k_0} \sqrt{(m_0^2 + 1)}$$

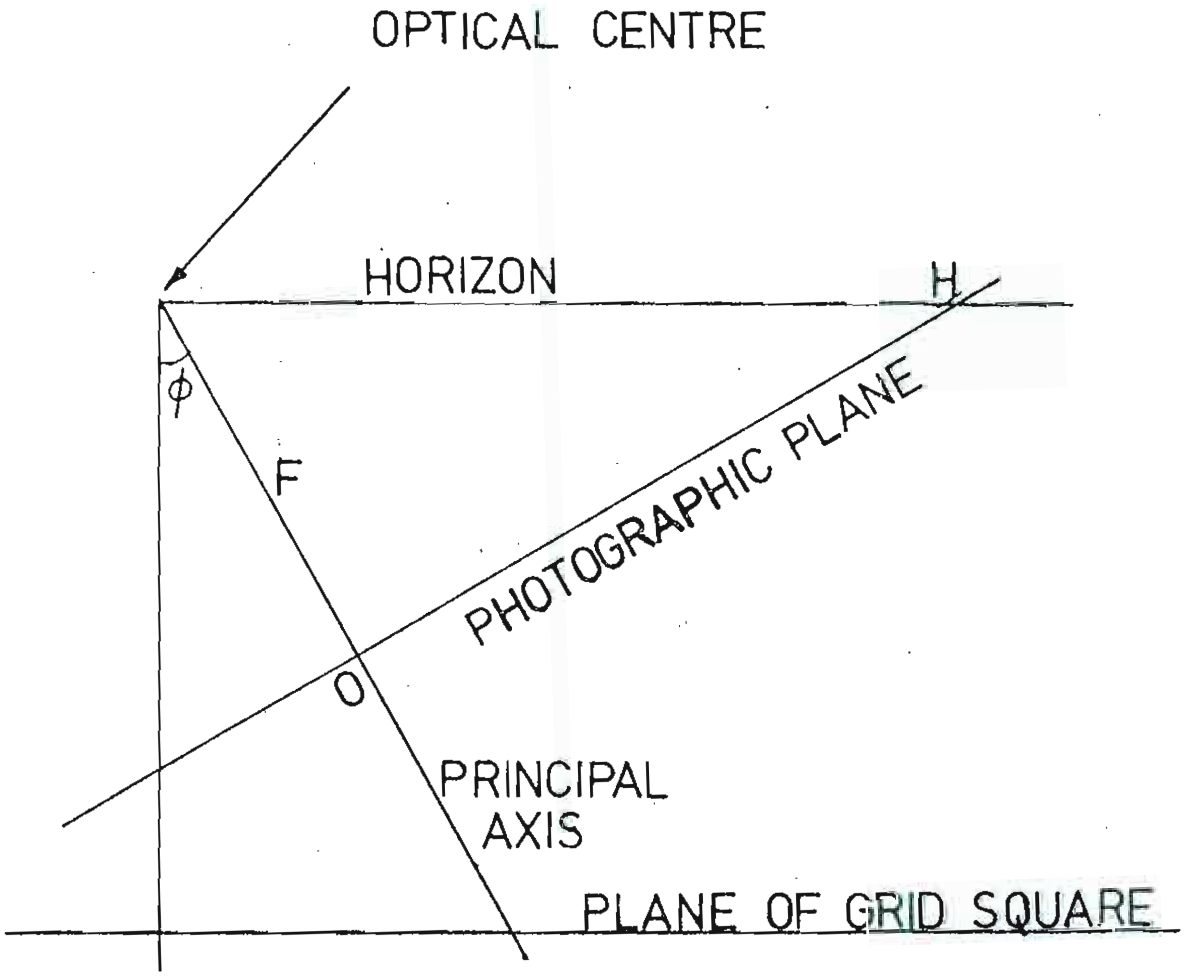
where F is the effective local length of the print or F = mf where f is

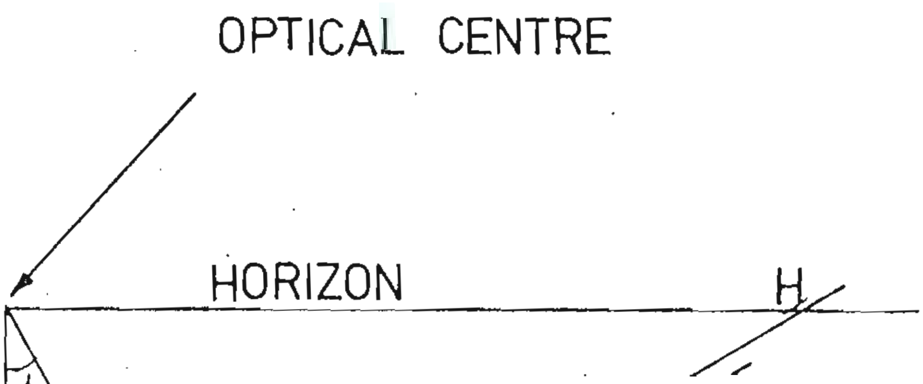
$$X_{02} = \frac{k_4 - k_3}{m_3 - m_4} \qquad Y_{02} = m_4 X_{02} + k_4$$

The equation of the line formed by these two points, the horizon line is:

$$Y = m_0 X + k_0 \text{ where } m_0 = \frac{Y_{01} - Y_{02}}{X_{01} - X_{02}} \text{ and } k_0 = \frac{X_{01} Y_{02} - X_{02} Y_{01}}{X_{01} - X_{02}}$$

The perpendicular to the horizon line from the origin, meets the horizon line at co-ordinate: X_h; Y_h. This is the azimuth


OPTICAL CENTRE
HORIZON
H
ϕ
F
PHOTOGRAPHIC PLANE
O
PRINCIPAL
AXIS
PLANE OF GRID SQUARE


OPTICAL CENTRE
HORIZON
H

4. Co-ordinate Transform Programme

During the excavation of the James Mathews, (see Henderson, 1976 and Baker and Henderson, 1979) the co-ordinates of the internal hull structure were measured relative to a three dimensional rectangular co-ordinate system. The plane of the X and Y co-ordinates corresponding with the true horizontal plane. Subsequently, the angles made by the axes of the ship to this co-ordinate system were measured. In order to plot the horizontal, vertical end elevations, relative to the axes of the ship, the co-ordinates relative to the measuring system had to be transformed to the new co-ordinate system. If the first co-ordinate system is X^1, Y^1, and Z^1 (related to the true horizontal) we can apply a rotation w about the X^1 axis. This gives a new co-ordinate system:

$$X_1 = X^1$$

$$Y_1 = Y^1 \text{ Cosw} + Z^1 \text{ Sinw}$$

$$Z_1 = -Y^1 \text{ Sinw} + Z^1 \text{ Cosw}$$

If the second rotation is ϕ about the Y_1 axis, then the new co-ordinate system is X_2, Y_2 and Z_2.

where $X_2 = - Z_1 \text{ Sin}\phi + X_1 \text{ Cos}\phi$

$$Y_2 = Y_1$$

$$Z_2 = Z_1 \text{ Cos}\phi + X_1 \text{ Sin}\phi$$

The third rotation k is about the

Z_2 axis giving X, Y and Z.

where $X = X_2 \text{ Cosk} + Y_2 \text{Sin k}$

relative to the axes of the ship, the co-ordinates relative to the measuring system had to be transformed to the new co-ordinate system. If the first co-ordinate system is X^1, Y^1, and Z^1 (related to the true horizontal) we can apply a rotation w about the X^1 axis. This gives a new co-ordinate system:

$$X_1 = X^1$$

$$Y_1 = Y^1 \text{ Cosw} + Z^1 \text{ Sinw}$$

$$Z_1 = -Y^1 \text{ Sinw} + Z^1 \text{ Cosw}$$

If the second rotation is ϕ about the Y_1 axis, then the new co-ordinate system is X_2, Y_2 and Z_2.

This is the co-ordinate system of the ship where:

$$X = X^1 (\mathrm{Cos}\phi\ \mathrm{Cosk}) + Y^1 (\mathrm{Sinw}\ \mathrm{Sin}\phi\ \mathrm{Cosk} + \mathrm{Cosw}\ \mathrm{Sink})$$

$$+ Z^1 (- \mathrm{Cosw}\ \mathrm{Sin}\phi\ \mathrm{Cosk} + \mathrm{Sinw}\ \mathrm{Sink})$$

$$Y = X^1 (-\mathrm{Cos}\phi\ \mathrm{Sink}) + Y^1 (-\mathrm{Sinw}\ \mathrm{Sin}\phi\ \mathrm{Sink} + \mathrm{Cosw}\ \mathrm{Cosk})$$

$$+ Z^1 (\mathrm{Cosw}\ \mathrm{Sin}\phi\ \mathrm{Sink} + \mathrm{Sin}\ w\ \mathrm{Cosk})$$

$$Z = X^1 (\mathrm{Sin}\phi) + Y^1 (-\mathrm{Sin}\ w\ \mathrm{Cos}\phi) + Z^1 (\mathrm{Cosw}\ \mathrm{Cos}\phi)$$

Since the angles are known, the co-ordinates of each point are entered in the machine, and the printout gives the true co-ordinates. The calculation is really quite simple but would be prohibitively long and tedious if done manually.

The author feels that those types of instruments will open a new field in underwater surveying, the applications outlined here are of course only some of the possibilities.

I would like to acknowledge the support of the Australian Research Grant Committee who have generously funded this research.

References

Green, J.N., 1978,

Appendix 1: The survey procedure
In R.C.M. Piercy, The Mombasa wreck excavation. Second interim report, 1978
I.J.N.A., 7.4: 311 - 314.

Piercy, R.C., 1977,

Mombasa Wreck Excavation Preliminary Report, 1977.
I.J.N.A., 7.4: 331 - 347.

Baker, P.E. and Green, J.N., 1976,

Recording techniques used during the excavation of the Batavia.
I.J.N.A., 5.2: 143 - 158.

$$+ Z^1 (\mathrm{Cosw}\ \mathrm{Sin}\phi\ \mathrm{Sink} + \mathrm{Sin}\ w\ \mathrm{Cosk})$$

$$Z = X^1 (\mathrm{Sin}\phi) + Y^1 (-\mathrm{Sin}\ w\ \mathrm{Cos}\phi) + Z^1 (\mathrm{Cosw}\ \mathrm{Cos}\phi)$$

Since the angles are known, the co-ordinates of each point are entered in the machine, and the printout gives the true co-ordinates. The calculation is really quite simple but would be prohibitively long and tedious if done manually.

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I would like to acknowledge the support of the Australian Research Grant Committee who have generously funded this research.

References

Appendix 4.4.

List of illustrations and sources relating to the waterport of the Castle of Batavia.

4.4 Appendix 4

List of illustrations and sourćes relating to the waterport of the Castle of Batavia.

(a) Rijksarchief, 's-Gravenhage.

Manuscript plans:

- i RA 1176 Plan of fort Jacrata dated 7 Cctober 1619
- ii KOLA 79 Plan of town of Batavia dated 1627
- iii RA 1178 Plan of Batavia dated 1628 by Fran Berkeroode
- iv RA 1179 The town of Batavia dated 1629 by Jacobcuyck
- v RA 1180 View of Batavia Roads by J. Nessel c̄ 1650
- vi RA 1181 Plan of Batavia c̄ 1650 vingbooms

(b) Scheepvaart Museum, Amsterdam.

Printed publications:

1. Historiche Beschryving der Reizen.

   Anon, Amsterdam, 1755. AIV/I 61, deel 12.
   p 526 Batavia 1731-50 engraved Schley.
   p 523 Batavia assiege en 1629 engraved Schley.

2. Korte Historiael.

   P. van den Broecke Amsterdam 1634. FMh 1055A.
   p. 124 Batavia (1629 under seige) engraved Matham

3. Vies de Gouverneurs Generaux.

   J.P. du Bois, Hague, 1763. B III 31.
   p. 91 Batavia assiege en 1629 engraved Schley.

4. Oude en Niew Oost Indien.

   F. Valentyne, Amsterdam, 1726. GR 77/49 deel 4.
   p. 91 Batavia belegred 1629 engraved F. Ottens.

5. Begin en Voortgang.

- iii RA 1178 Plan of Batavia dated 1628 by Fran Berkeroode
- iv RA 1179 The town of Batavia dated 1629 by Jacobcuyck
- v RA 1180 View of Batavia Roads by J. Nessel c̄ 1650
- vi RA 1181 Plan of Batavia c̄ 1650 vingbooms

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1. Historiche Beschryving der Reizen.

   Anon, Amsterdam, 1755. AIV/I 61, deel 12.
   p 526 Batavia 1731-50 engraved Schley.

(c) Rijksmuseum Amsterdam.

1. Atlas Muller, Amsterdam, 1882.

Vol. 4 No. 1600 Plan of Batavia 1628 F. van Berckeroode.
No. 1601 Plan of Batavia 1629 G. Venant.

2. Atlas Stolk, Amsterdam, 1897.

Vol. 2 No. 1671 From van den Broeck 1629.
No. 1724 Belag van Batavia 1630.
No. 2355 Batavia pieter van Hoorn 1666/7.

3. Gedenkwaerdige zee- en land-reizen

J. Nieuhof, Amsterdam, 1692 Rm 301-c-7.
p. 196-7 Land Carte van Batavia.
p. 196-7 Die Nieuw Poort van het Castel.
p. 197 View of Batavia.

4. Oude Batavia Gedenkboeck.

Anon, Batavia, 1922.
Atlas E2 stone belonging to land port.
G8 Specx's medallion showing plan of Batavia in 1632.
K13 View of new port.
K9 View of new water-port.
K10 View of the Castle.

(d) University Library, Leiden

1. J. Janssonius Atlas, 1558-62.
Plan of Batavia in 1652.

2. Manuscript plan of Batavia in 1621. Reference from
Catalogues van 300 javrig bestaan van Batavia in
Stedilijk museum, Amsterdam, Juli 1919.

(e) Royal Library, 's-Gravenhage.

Atlas of P. van der Aa. ref. I/27
Vol. 57 Nos. 18, 19, 20, 21 and 22.

3. Gedenkwaerdige zee- en land-reizen

J. Nieuhof, Amsterdam, 1692 Rm 301-c-7.
p. 196-7 Land Carte van Batavia.
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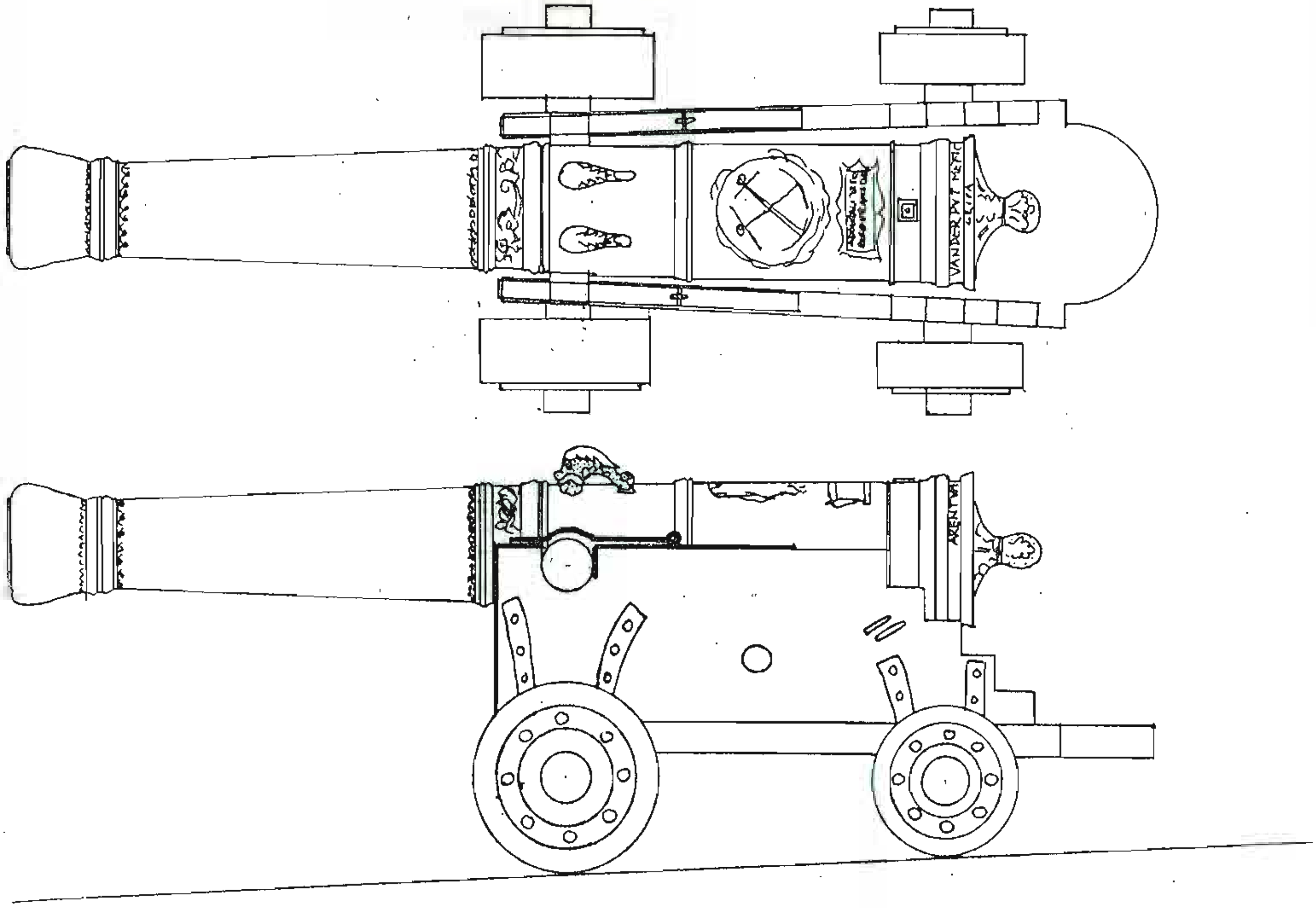
Atlas E2 stone belonging to land port.
G8 Specx's medallion showing plan of Batavia in 1632.
K13 View of new port.
K9 View of new water-port.
K10 View of the Castle.

(d) University Library, Leiden

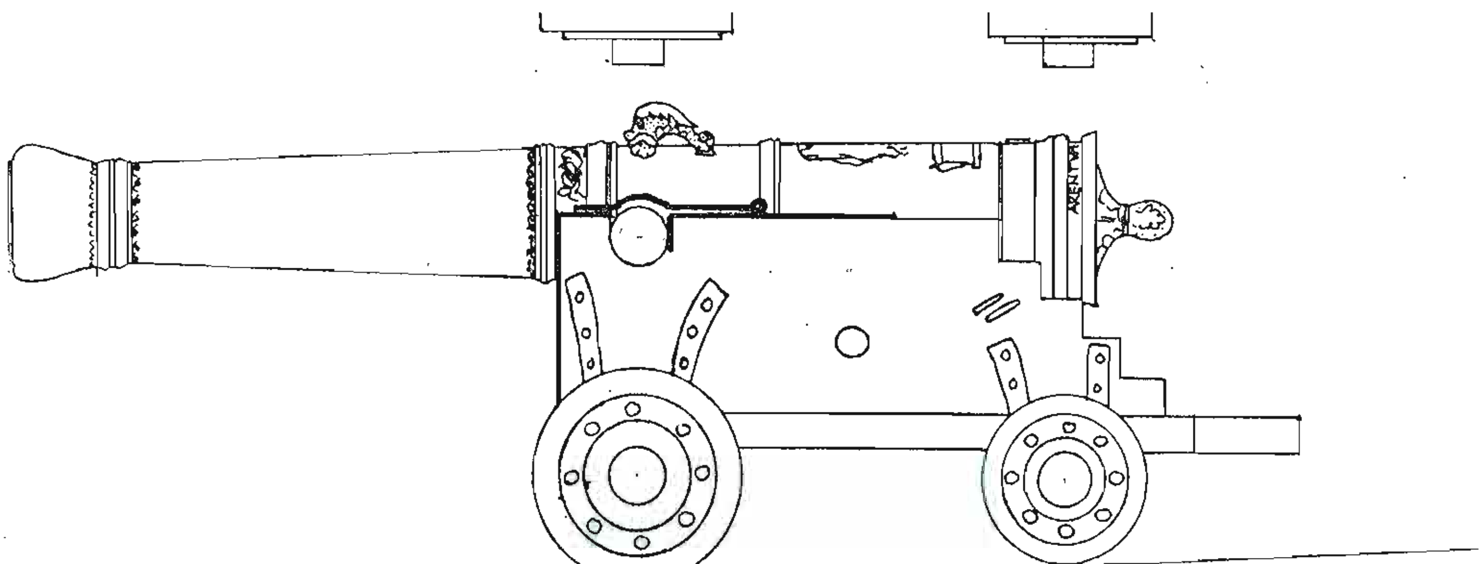
Appendix 4.5.

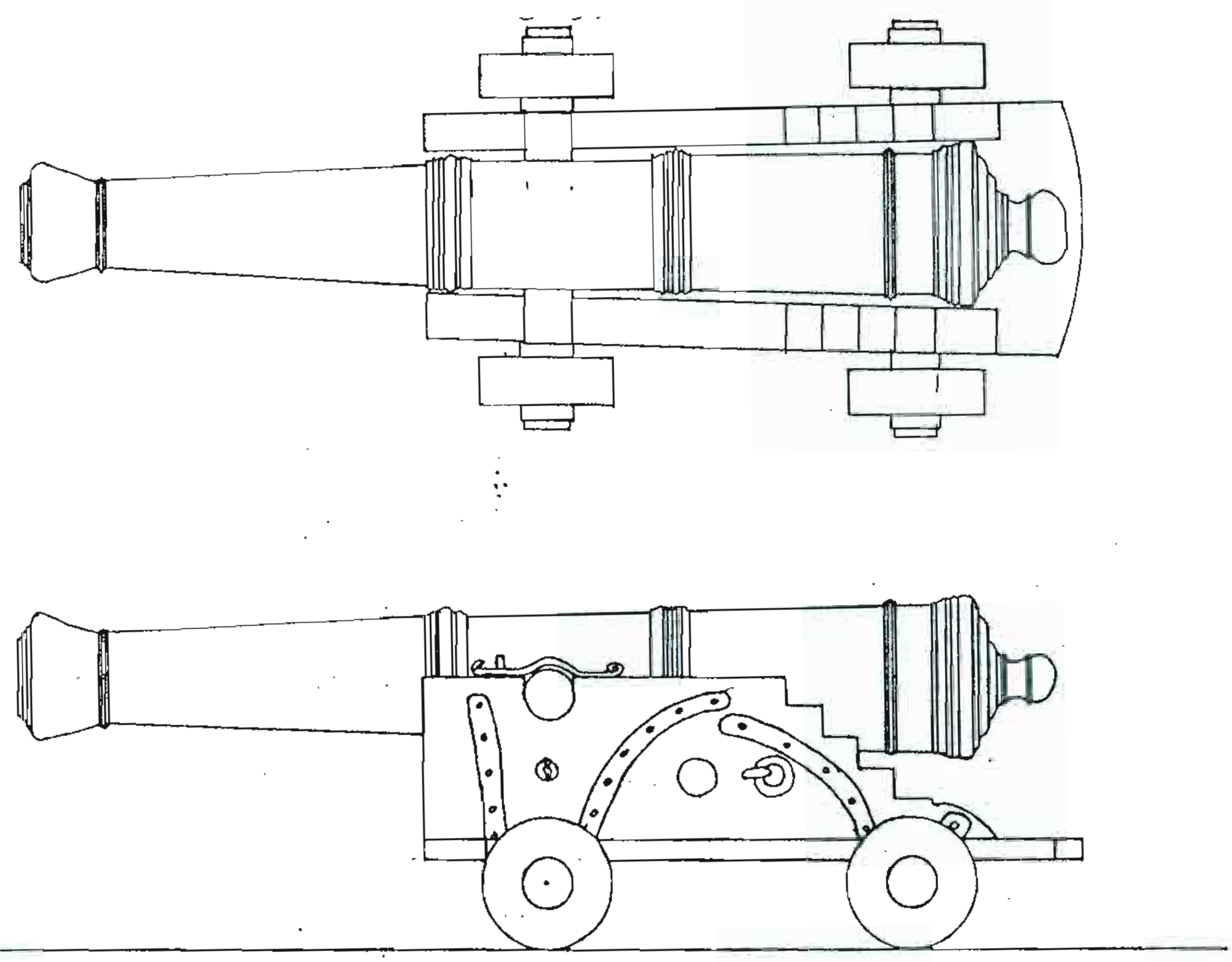
Plans of gun carriages suitable for Batavia, Vergulde Draeck and James guns



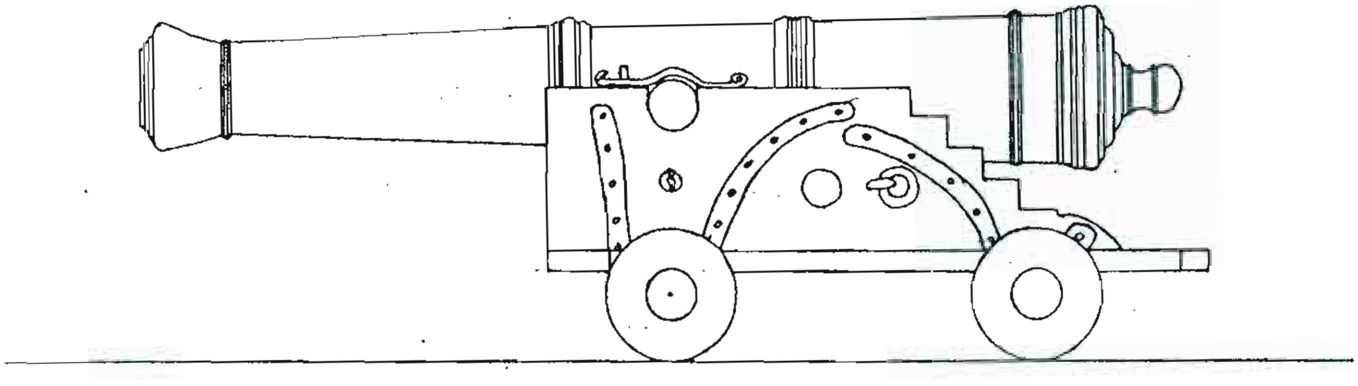
GUN CARRIAGE SUITABLE FOR

BATAVIA CANNON

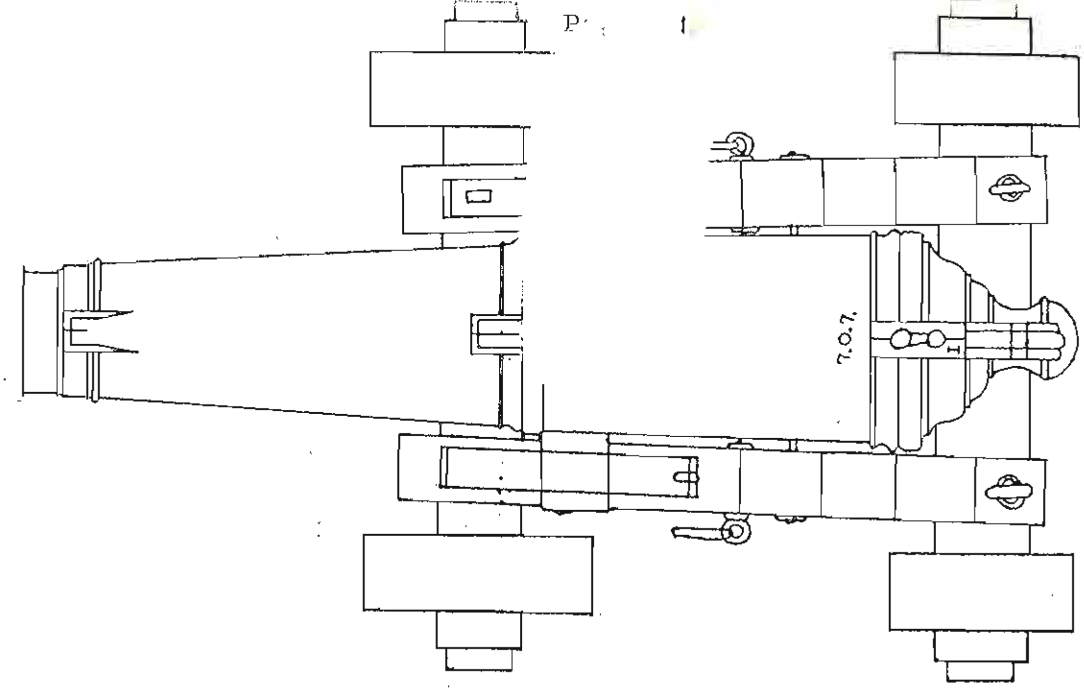


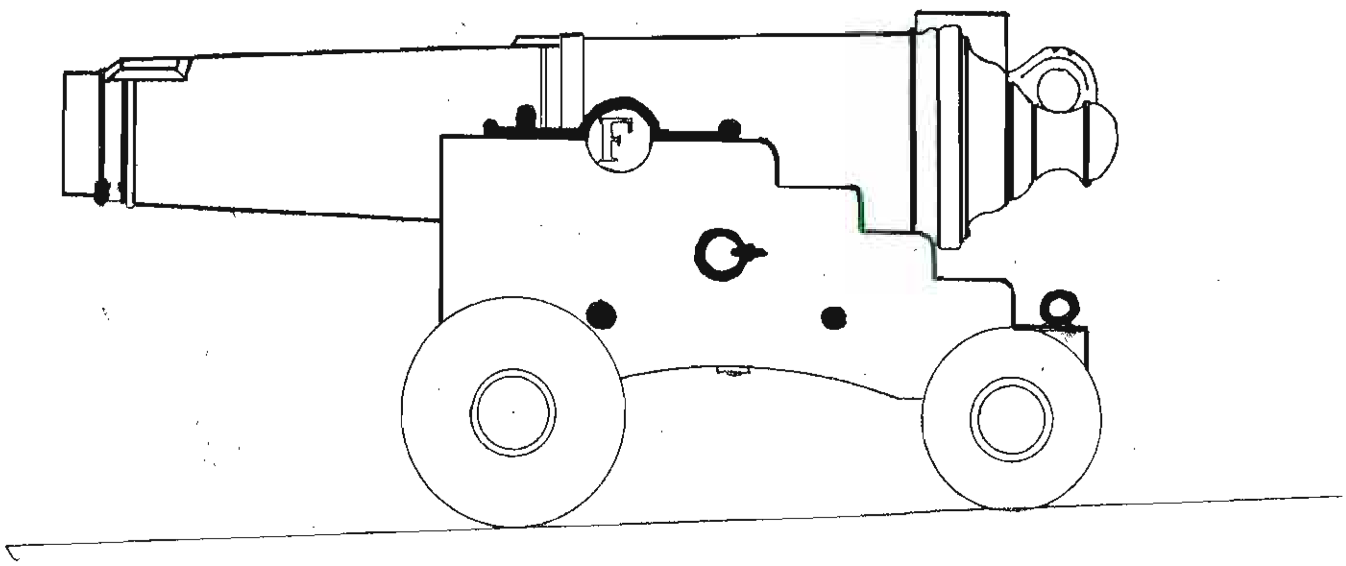


GUN CARRIAGE SUITABLE FOR
VERGULDE DRAECK CANNON

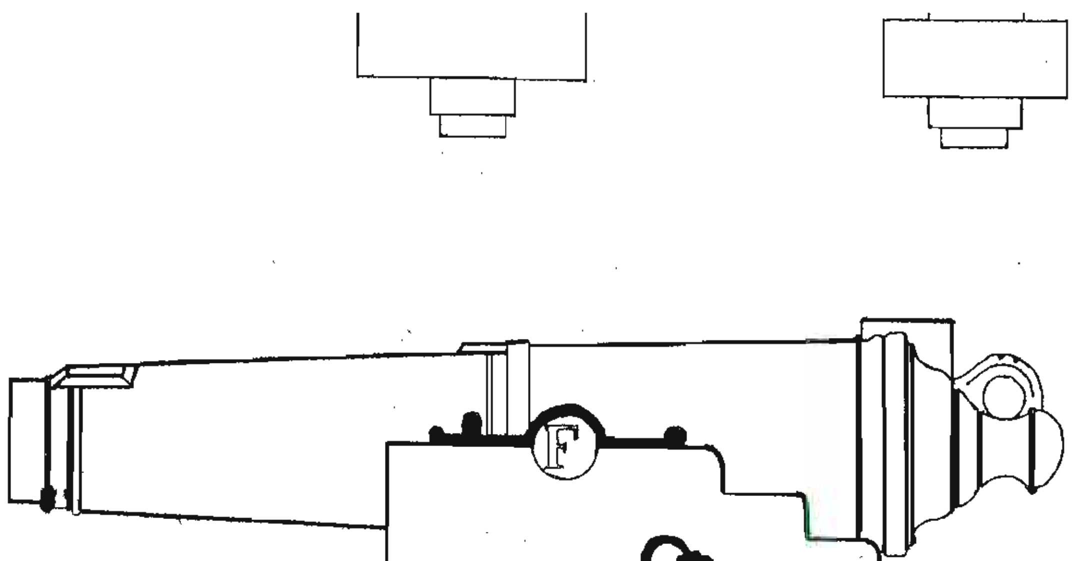


GUN CARRIAGE SUITABLE FOR



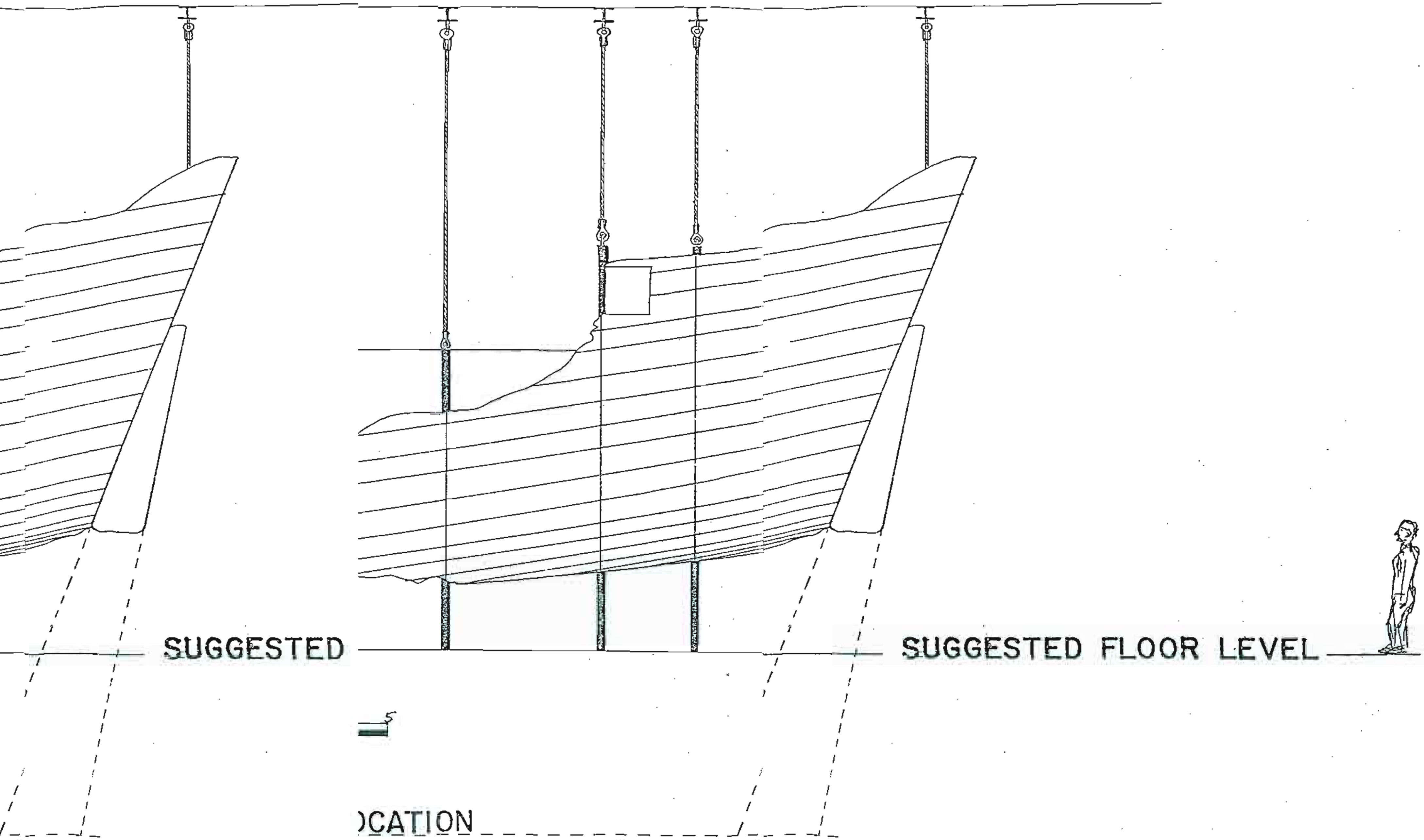


GUN CARRIAGE SUITABLE FOR THE
JAMES CARRONADE



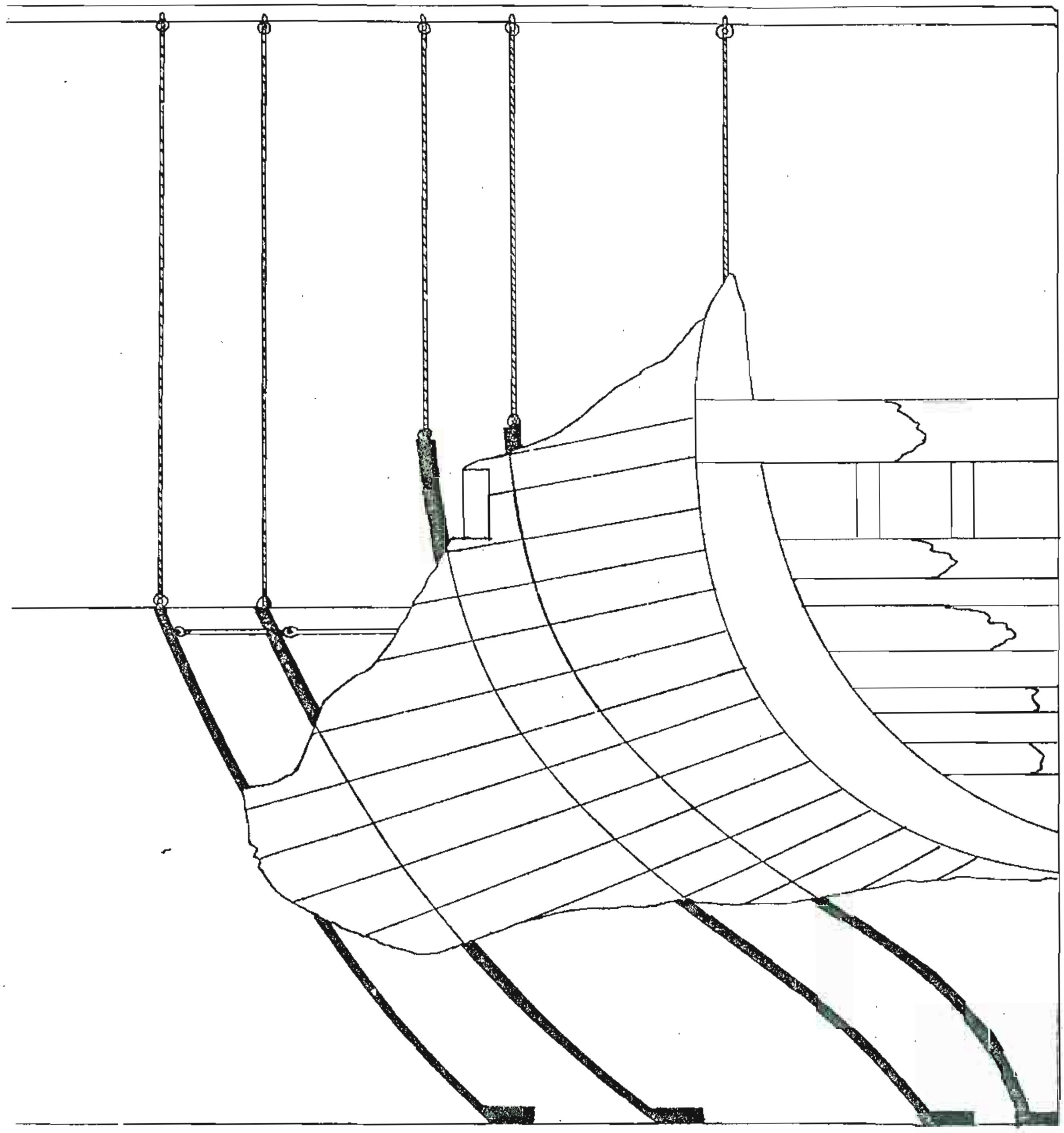
Appendix 4.6.

Side, end and plan elevations of Batavia reconstruction.



)CATION

avia showing suggested ground floor level
level of gun deck. Wire supports shown
ers, and black areas side view of support



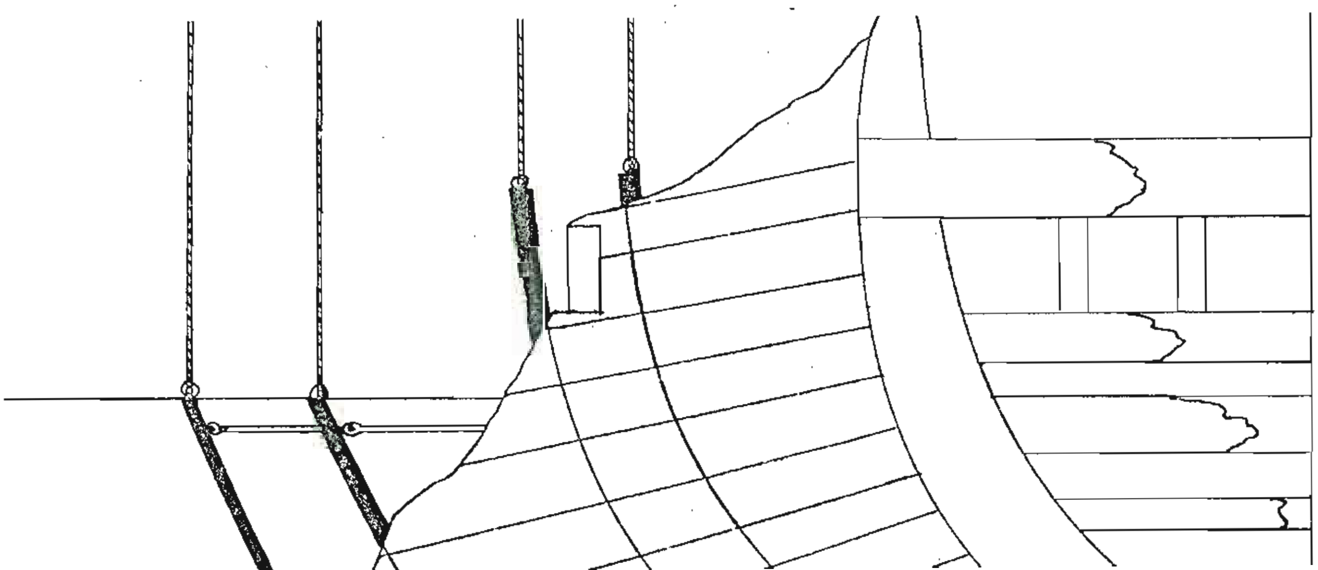
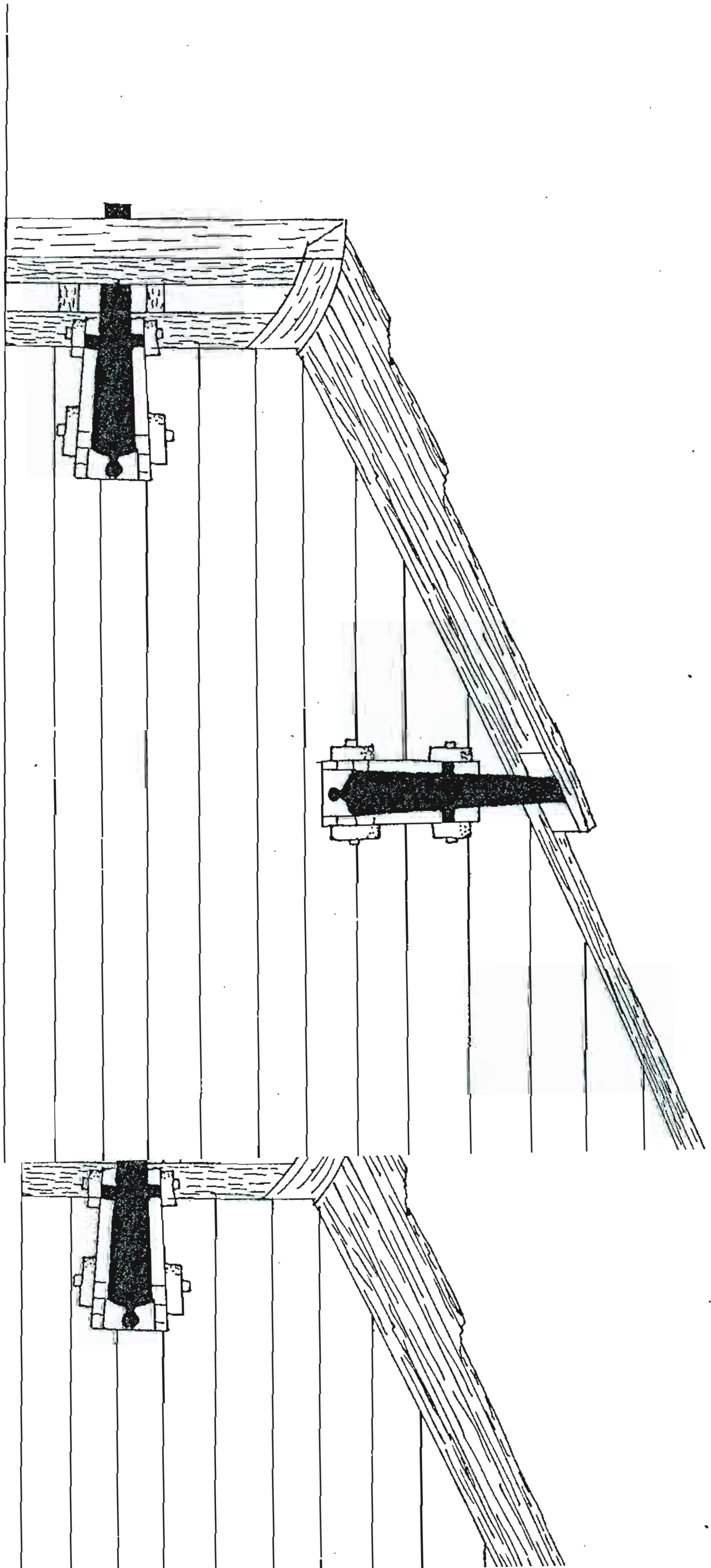
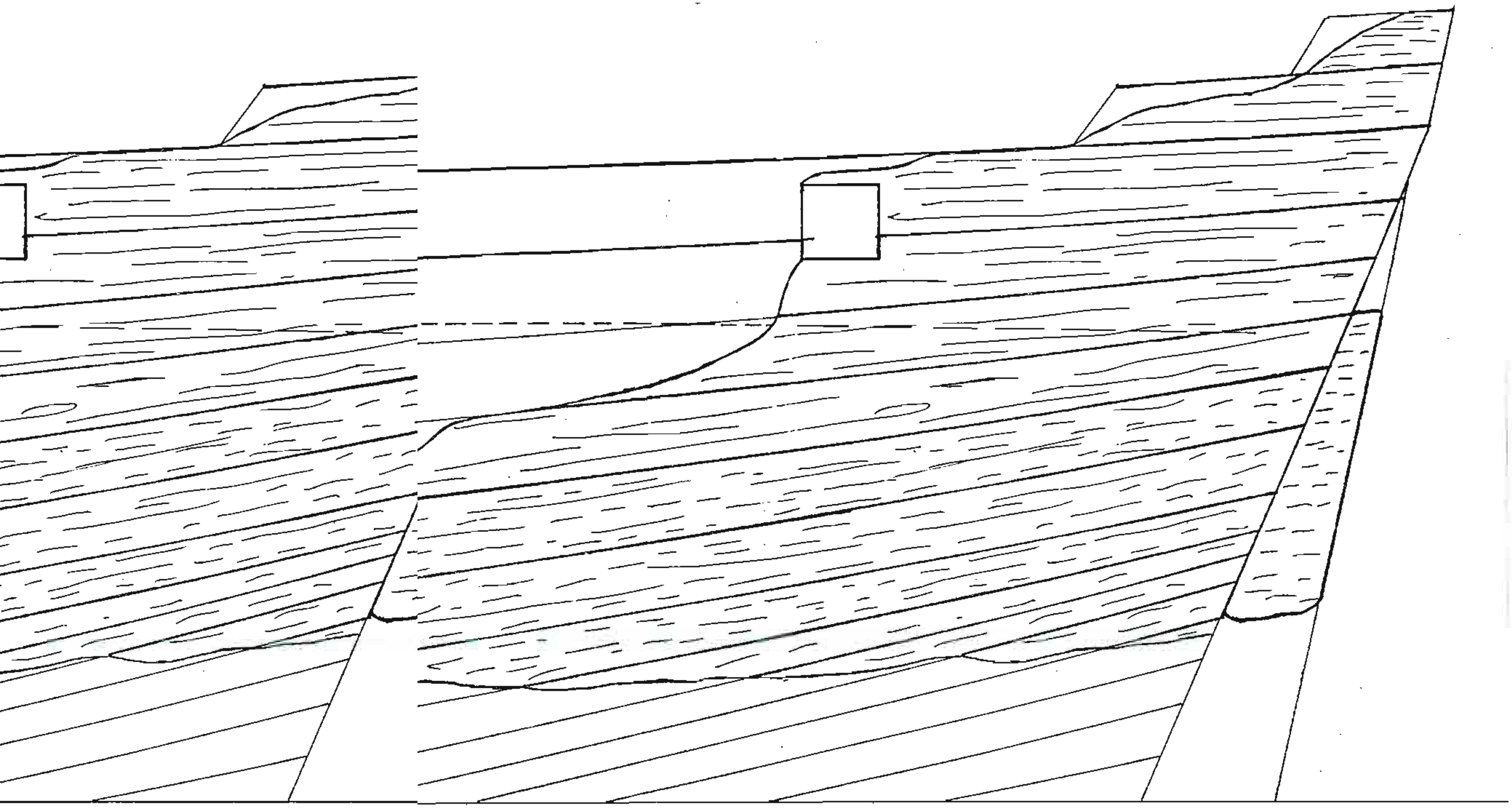


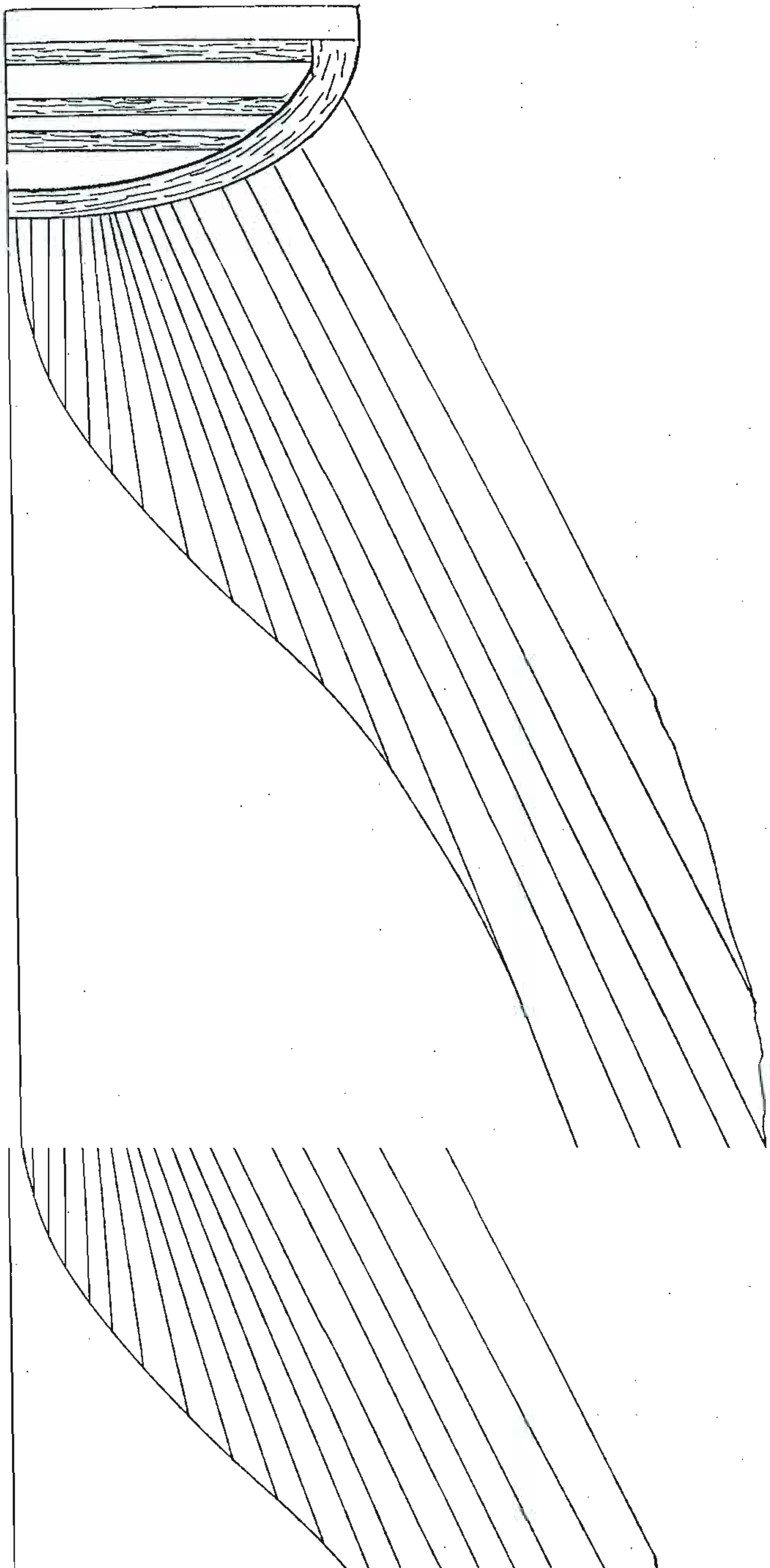
Fig. 3. First floor plan of reconstruction showing hypothetical available floor area and reconstructed gun carrages.

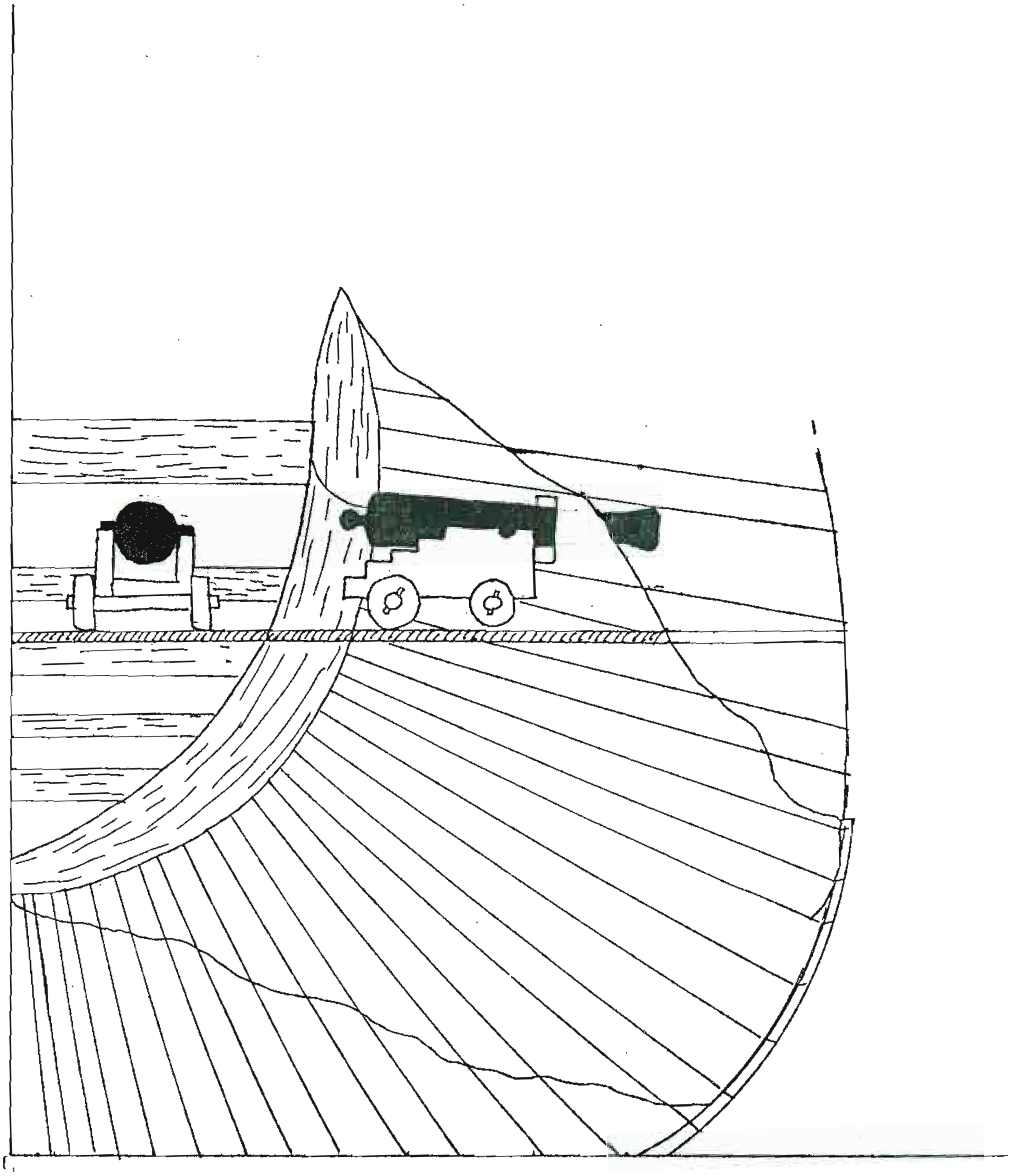


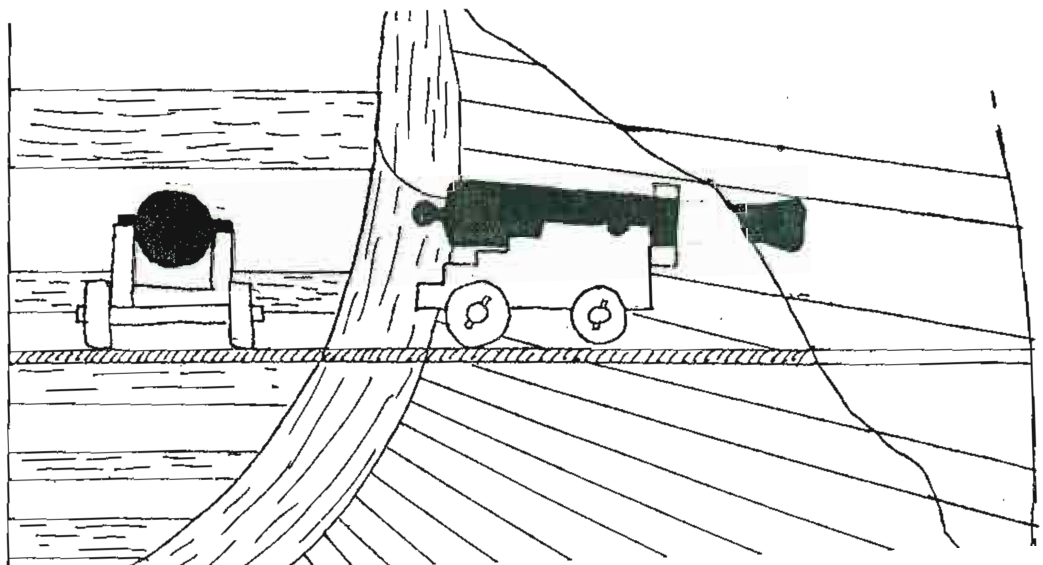


de elevation showing possible future reconstruction (clear
eas). This reconstruction would seal the hold off from the
tside, and provide a reasonable bulwark height along the
de on the first floor.

future reconstruction (clear
ld seal the hold off from the
e bulwark height along the







Appendix 4.7.

List of weights and offsets of Batavia timber.

4.7 Appendix

List of weights and offsets of Batavia timber

The weights are calculated from the volume of timber assuming a S.G. of 1.

WEIGHTS

SECTION 1	up to first saw cut	1.57 tons
SECTION 2	from 1st to 2nd cut	1.78 tons
SECTION 3	from 2nd to 3rd cut	2.48 tons
SECTION 4	from 3rd cut to transom	6.19 tons
SECTION 5	transom including knees	4.00 tons

OFFSETS

Stations	HORIZONTAL	HORIZONTAL TOPS OF FRAME	VERTICAL TO TOP OF FRAME
END	10.0	13.2	9.5
CUT 1	8.0	13.2	9.5
CUT 2	4.5	10.5	6.7
CUT 3	2.0	9.0	6.7
TRANSOM	0	5.5	5.0

Figure 7.1 shows plans of ties and centres of mass of the five sections (1,2,3,4 and 5).

The first frame A is vertical support, B is base of frame and C is wall tie position.

The second	D vertical	E base	F wall
The third	G "	H "	J "
The fourth	K "	L "	M "

N is the vertical support for transom and tie FK is a brace.

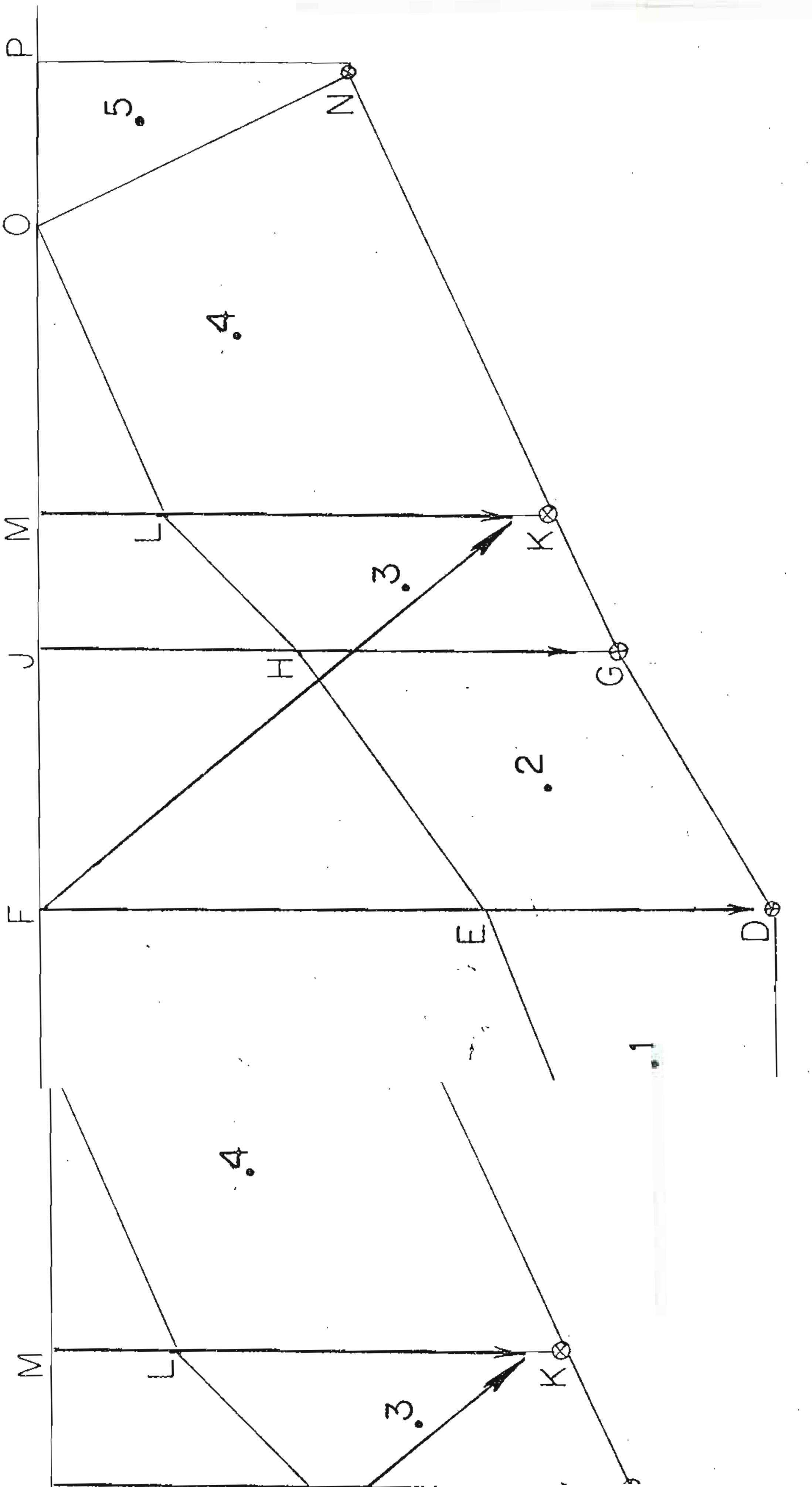
All ties lie below level of floor.

Figure 7.2 Shows schematic isometric drawing of the transom support

SECTION 3 from 2nd to 3rd cut 2.48 tons
SECTION 4 from 3rd cut to transom 6.19 tons
SECTION 5 transom including knees 4.00 tons

OFFSETS

Stations | HORIZONTAL | HORIZONTAL TOPS OF FRAME | VERTICAL TO TOP OF FRAME
END 10.0 13.2 9.5
CUT 1 8.0 13.2 9.5
CUT 2 4.5 10.5 6.7
CUT 3 2.0 9.0 6.7
TRANSOM 0 5.5 5.0


P
O
M
J
F
N
K
G
D
L
H
E
5.
4.
3.
2.
1.
4.
M
L
K
3.