UNITED ARAB REPUBLIC

MINISTRY OF CULTURE AND NATIONAL ORIENTATION

ANTIQUITIES DEPARTMENT OF EGYPT

THE CHEOPS BOATS

by

MOḤAMMAD ZAKI NOUR ZAKY ISKANDER

MOḤAMMAD SALAḤ OSMAN AḤMAD YOUSSOF MOUSTAFA

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A PRELIMINARY REPORT
ON
THE NEWLY DISCOVERED BOAT AT GIZA

BY

ZAKI NOUR

THE DISCOVERY

Since 1940 the Department of Antiquities has followed the policy of excavating the mounds of the debris of various heights along both the eastern and western sides of the Great Pyramid at Giza.

Both sides could hardly be seen owing to these mounds, which consisted of sand and chips of stone which accumulated there through the course of time, and of debris dumped by previous excavations.

The endeavours of the Department were first directed to the eastern side.

The removal of the debris from the south east corner of the Pyramid has lead to the discovery of some mastabas (Fig. 1).

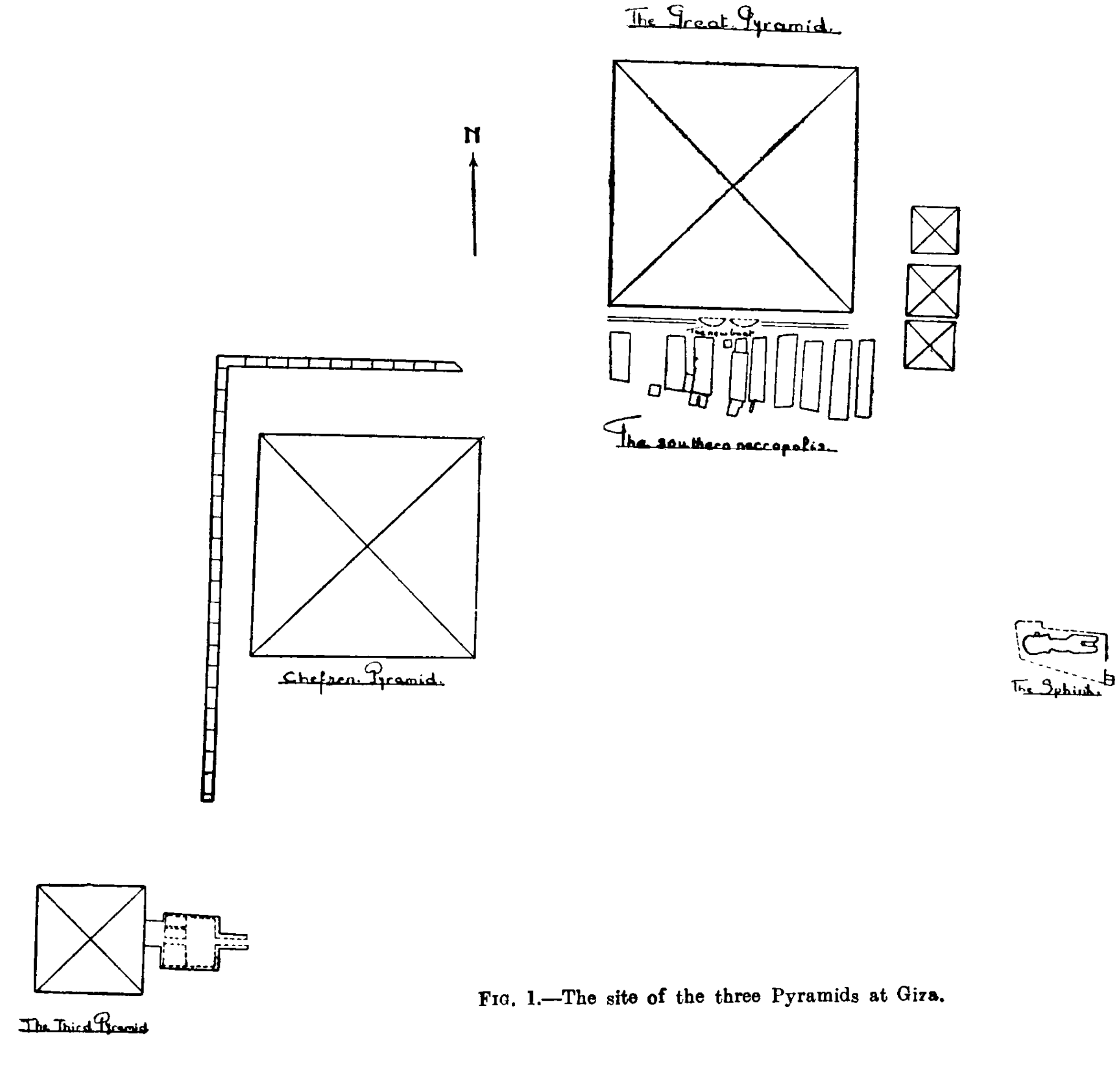

FIG. 1.—The site of the three Pyramids at Giza.

In November 1952 began the clearance of the debris that collected along the southern side of the Great Pyramid. This debris filled the whole southern court of the Pyramid and extended to the mastabas which constituted the southern necropolis of King Cheops (Pl. I). The debris was about 20 metres high as shown by the lighter colour of the stones of the pyramid that were hidden by it (Pl. II, A).

The removal of the debris was completed on April 22 nd., 1954.

The Southern Court of the Pyramid

The evacuation of the debris was carried out from the north to the south, with the result that the wide southern pavement of the Pyramid was completely cleared. It was thus found that the pavement was made of well dressed slabs of limestone about 55 cms thick. These slabs are similar to those paving the northern court of the same Pyramid.

The Southern Enclosure wall of the Pyramid

A part of a wall running parallel to the southern side of the Great Pyramid was at last revealed. It was the remnant of an enclosure wall which once surrounded the Pyramid along all sides except in the portion occupied by the mortuary temple.

The part of the southern wall which appeared first was to the west, and therefore the work continued eastwards until the whole wall was completely revealed (Pl. II, B).

We cannot tell its original height, but a part of it is now 1.66 m. high ; the wall is 206.55 m. long and lies about 18.50 m. from the southern side of the Pyramid.

There is evidence that this wall was connected with the western part of the enclosure wall at a distance of 23.60 metres from the western side of the Pyramid (Pl. III, A).

Owing to the complete disappearance of the eastern wall, we cannot trace the original connecting point between it and the southern wall. However, remains of the northern wall are still visible.

Thus, it can be concluded that the Great Pyramid was surrounded by an enclosure wall parallel to its northern, southern and western sides :

(*a*) The northern wall at a distance of 23.60 metres.

(*b*) The southern wall at a distance of 18.50 metres.

(*c*) The western wall at a distence of 23.60 metres.

The southern wall, like the western and northern walls, was built of small rubble masonry, most of which is of limestone and some of granite and basalt. The limestone pieces were most likely obtained from quarries in the area and were probably the remains left after the different kinds of work which had been carried out in the site. The wall was also coated on both sides with mud plaster about 6 cms thick. Most probably, the wall was coated with another layer of white plaster over the mud plaster so as to appear as if the whole wall was built of white limestone. This is similar to what took place in similar buildings during the Old Kingdom especially in the Fourth Dynasty (Pl. III, B).

This wall was slightly inclined towards the north. The same inclination has been observed in the walls of the sloping causeway of the Second Pyramid at Giza (Pl. IV, A).

The width of the part of the wall contacting the rocky plateau is 2.50 metres while the top is 2.25 metres wide only.

It seems that the building of the wall was carried out by several sets of labourers at the same time, as there are many joints denoting the completion of a certain part of the wall. These joints were completely cased with mud (Pls. IV, B and V, A). This has but one explanation, namely, that groups of labourers carried out the building simultaneously.

Opening the Pit and Finding the Boat

Underneath the wall was found a layer of compressed ground covering huge blocks of limestone placed one close to the other in a regular line parallel to the base of the Great Pyramid.

They were arranged in two rows to the east and to the west of a square rock of the plateau the centre of which lies exactly on the axis of the Pyramid. (Pl. V, B).

The row to the east consists of 41 blocks, and that to the west consists of 40 blocks.

In order to know what lies underneath those huge stones, it was found necessary to open a small hole in one of the eastern blocks (Pl. VI, A).

On 26th May 1954, the hole was made. Through this hole it was seen that the blocks were covering a pit occupied by a wooden boat. On the surface of the boat could be seen a steering oar, wooden boards, columns, beams and remains of matting, ropes, etc. (Pl. VI, B).

The part of the wall that covered the eastern blocks was removed, while a wooden roofed shelter was erected covering an area slightly wider than that occupied by the eastern group of blocks. This shelter was necessary for the safety of the parts of the boat after lifting up the blocks. (Pl. XVIII, A).

The blocks were then lifted up and removed to the southern court of the Great Pyramid under a wooden shed. The quarry marks found on the blocks were chemically treated for preservation and copied.

To keep a fixed and suitable degree of humidity in the pit, and to avoid severe disintegration due to excessive drying up, the director of the chemical laboratory advised that wooden boards should replace the huge blocks on the two ledges. As further precaution for the safety of the wood, these boards were also covered with water - and fire - proof cloth.

Scientific remarks from the archaeological, architectural and chemical points of view were duly registered ; moreover, all the steps carried out were recorded in pictures and designs in the course of work.

A laboratory was built in the site of the discovery for the treatment of the different parts of the boat in situ.

To avoid fire accidents a fire brigade station was established.

The lifting up of the blocks started on 23rd November 1954 and continued till 28th January 1955. The chemical treatment and lifting up of the remains of matting, ropes and fenders started on 25th March 1955 and continued till the end of June 1955.

LIFTING UP THE WOODEN PARTS OF THE BOAT AND THEIR PRESERVATION

In the Summer of 1955 a building (restoration studio) was constructed beside the pit, for the chemical treatment and restoration of the wooden parts of the boat.

On 17th December 1955 began the lifting up of the wooden parts of the boat. This process was completed during the seasons 1955 - 1956, and 1956 - 1957.

Mr. Hassan Zaki, the photographer of the Department, managed to make one complete picture for the whole surface of each layer which facilitated the registration.

Mr. Ahmed Youssef, the chief of restoration, was charged with lifting up the wooden ports of the boat from the pit and transferring them to the restoration studio.

Dr. Zaky Iskander, the director of the chemical laboratory, and myself collaborated to describe in detail every piece of the boat after lifting it up from the pit. This description was recorded in a special register book in Arabic and in cards in English.

Dr. Zaky Iskander was also concerned with the chemical treatment of the wooden parts of the boat with plastic solutions to prevent their decay.

The whole number of the pieces is 651, which were found arranged in thirteen layers On the floor of the pit were found a great quantity ot ropes which were mostly disintegrated; nevertheless a good part of these ropes could be preserved.

In the season 1957 - 1958 started the process of reconstructing the boat for exhibition in a local museum.

It should be mentioned that this report does not refer to the western pit and its huge blocks as this is still untouched. It is probable that this western pit contains another boat, because of the same architectural characteristics in both the eastern and western blocks on which extends the same wall. It was agreed to postpone the opening of the second pit until we finish or nearly finish the study of the eastern boat.

I am now going to deal briefly with the following :

(1) Dating the southern enclosure wall.

(2) The limestone blocks.

(3) The pit.

(4) The quarry marks.

(5) A description of the Boat.

1.—Dating the southern enclosure wall

The poor materials and primitive method employed for building this southern enclosure wall compared with those employed during the Fourth Dynasty may suggest that this wall was built during a later period. I think, however, that it was built during the reign of Ḏedefré or at least during the reign of one of his successors of the same Dynasty.

This can be concluded from the following:

1.—As will be mentioned later (p. 7) 18 cartouches bearing the name of King Ḏedefré were found on some of the blocks covering the pit. Since the wall was built over the blocks, this wall must have been built during his reign at the earliest.

2.— The Second Pyramid of Chephren was surrounded by a wall, the remnants of which are still visible in its eastern side and connected with both northern and southern walls of the mortuary temple.

This wall was erected in the same way as the southern one of the Great Pyramid, i.e. composed of small pieces of stone and coated with mud plaster (Pl. VII, A). This does not, mean that the southern wall of the Great Pyramid must have been built during the reign of Chephren, but it seems that this method was the one employed in the Fourth Dynasty.

3.—It was observed that the northern and southern surfaces of the wall were coated with a layer of mud plaster about 6 cms. thick (Pl. VII, B). This layer coated also the compressed ground to the south of the wall and extended underneath the northern side of mastaba No. 5 excavated by Prof. Doctor Hermann Junker. This means that this wall and the muddy layer which extended from the wall to the south must precede the period of the building of that mastaba.

2.—The limestone blocks

These huge blocks are of various sizes and were employed as a roof for the pit containing the boat. The row of the blocks ended to the west with three stones of medium size (key stones).

At first, there appeared only the upper surfaces of the blocks which were not on the same level. To reach one and the same level, the Egyptians filled the gaps with a sort of compressed ground about 40 cms thick, composed of powdered limestone mixed with a gravel of limestone chips, small scraps of wood (Pl. VIII) and small fragments of charcoal, as will be explained in detail in the scientific report by Dr. Zaky Iskander. This layer was very compact and some parts of it adhered so strongly to the blocks that it was found very difficult to separate.

On lifting up the blocks, it was noticed that between most of them and the two rocky sides (the north and the south sides of the pit), there were small pieces of limestone used as shutters to reinforce the blocks in their proper places on the two ledges of the pit.

In order to facilitate the movement of the blocks, the Egyptians cut one or two square holes in the upper part of the northern and southern sides of each block and two or four holes in the western side of the block.

Most probably also, the semi circular hole which was carved in the rock of the plateau 7.55m. far from the east end of the pit, and the three other holes which were carved 3.70 m. far from the same side of the pit (Pl. IX, A) were also concerned with the process of moving the blocks from one place to another.

It is also worth mentioning here that a rectangular hole was carved in the rock of the plateau to the west of the western pit for the same purpose. (Pl. IX, B).

It seems as though the Ancient Egyptians were anxious to protect the boat against the penetration of rain water and insects, and to this end they used very fine liquid plaster in order to fill the gaps on the side surface of each block which remained after chiseling. Moreover, the plaster in question assisted in linking the blocks together.

This accounts for the fairly good state of the wooden boat, for it was preserved in an air-tight pit for thousands of years.

3.—The Pit

The pit which contained the boat was hewn in the solid rock of the plateau in the southern court of the Great Pyramid 17.85 m. far from its southern side. This was performed in a unique type, namely rectangular, a style which in fact was never discovered before. All that had been found were pits cut in the main rock in the form of boats (Pl. X, A). This may be accounted for by the fact that wood is a perishable material.

Of that style cut in the rock, we can mention the three pits to the east of the Great Pyramid, the pit lying between the Pyramids of Cheops'wives (Pl. X, B), and the five other pits near the Second Pyramid.

The upper part of the pit in which the limestone blocks were arranged is 32.5 m. in length, and 5.0 m. in width.

Two ledges at a distance 3.45 m. from its bottom were cut along all the sides of the pit. These ledges are about one metre wide and were cut to support the huge blocks. The whole depth of the pit including the upper part is 5.35 m.

Two points deserve special attention:

1.—At a distance of 3.25 m. from the bottom of the pit, a red straight line can be still seen clearly on the upper parts of the walls of the pit. No doubt, this was to adjust the accurate dimensions downwards in digging the pit. Hence, the four walls of the pit were found equally high and the bottom was found exactly flat.

2.—41 roughly circular holes were hewn at equal distances in the rock along the upper surface of each of the two ledges in such a way that every two opposite holes coincided with the middle of the two supports of each block. These holes were found filled with a mud mortar. (Pl. XXIV, A).

Some reddish signs were found on the southern wall of the pit denoting measures the exact meaning of which yet remains to be determined (Fig. **2**).

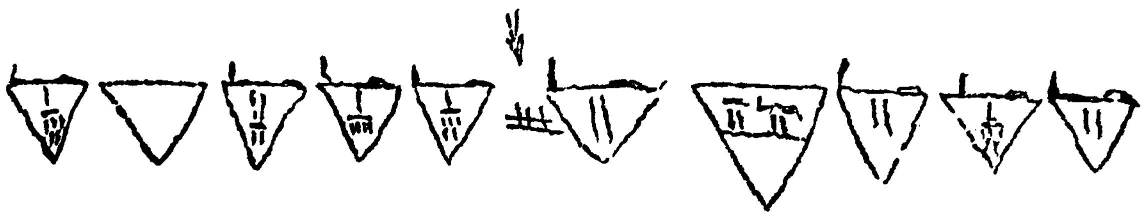

FIG. 2.—The red signs on the southern wall of the Pit

4.—The quarry marks

There were also found some reddish quarry marks on the surface of the huge blocks after the removal of the compressed layer previously mentioned. Other reddish or blackish marks were also found mostly on the northern, southern and lower surfaces of the blocks.

Eighteen cartouches bearing the name of King Dedefré, the builder of the incomplete Pyramid at Abu-Roash were found among the quarry marks on the upper surfaces of blocks Nos. 15, 19, 20, 23, 30, 34, 35 and 40, the lower surfaces of blocks Nos. 5, 7, 9 and 20, the northern sides of blocks Nos. 34 and 38, and the eastern sides of blocks Nos. 5 and 33 (Pl. XI, A).

It is obvious therefore, that this king had succeeded King Cheops. Consequently, the assumption of some historians that King Dedefré ruled at the end of the Fourth Dynasty is untrue.

Though Dedefré did not build the discovered boat for his father, he at least completed it. History is full of such examples.

On the lower surfaces of blocks Nos. 2,4,5,6,7,8,9,10,11,12,13,15,16,17,20 and 40, the marks include some measures, namely, the length, width and the height, the unit of which was the Ancient Egyptian cubit which was 52.3 cms. (Pl. XI, B).

An account of all the marks will be given after their decipherment and study.

5.—A description of the Boat

At first, after the lifting up of the blocks, there appeared on the surface of the boat traces of mats, ropes, fenders and small white pieces of plaster which dropped from between the blocks.

Although the parts of the boat were dismantled, they were arranged in the pit in such a way as to give the outlines of a boat.

First, in the extreme west, the most conspicuous piece was a wooden column which formed the prow of the boat. It is in the form of a cylindrical bundle of stems of papyrus with high relief representing five symbolic ropes. The top of the column is crowned with a wooden round disc broken in two pieces. (Pl. XLIV). The column was connected in its lower part with two long wooden pieces extending in the bottom of the pit. In the same side there were several longitudinal and transverse wooden planks and poles.

On the middle part of the boat, after the planks referred to, was a rhomboidal board of two separate pieces painted white, followed by a number of framed wooden boards over which was lying the steering oar.

In the extreme east, there was found another column in the form of a bundle of stems of papyus resembling that in the prow, no doubt it is for the stern.

Most of the parts were attached together with wooden cross beams, side-dowls, and wooden pegs inside grooves and stuck with an adhesive paste. Defects in the wood were repaired by inserting into them pieces of the same form fixed with small wooden pegs and adhesive paste.

Some copper staples which were employed as eyebolts, or for ropes were found in some pieces. Ropes were also found tied with different types of knots (Pl. XII).

Some signs in red or black colour and others incised in the wood were noticed on some pieces (Fig. 3). These perhaps had a close relation with the ancient technical terms of the different parts of the boat. This will be ascertained after the scientific study.

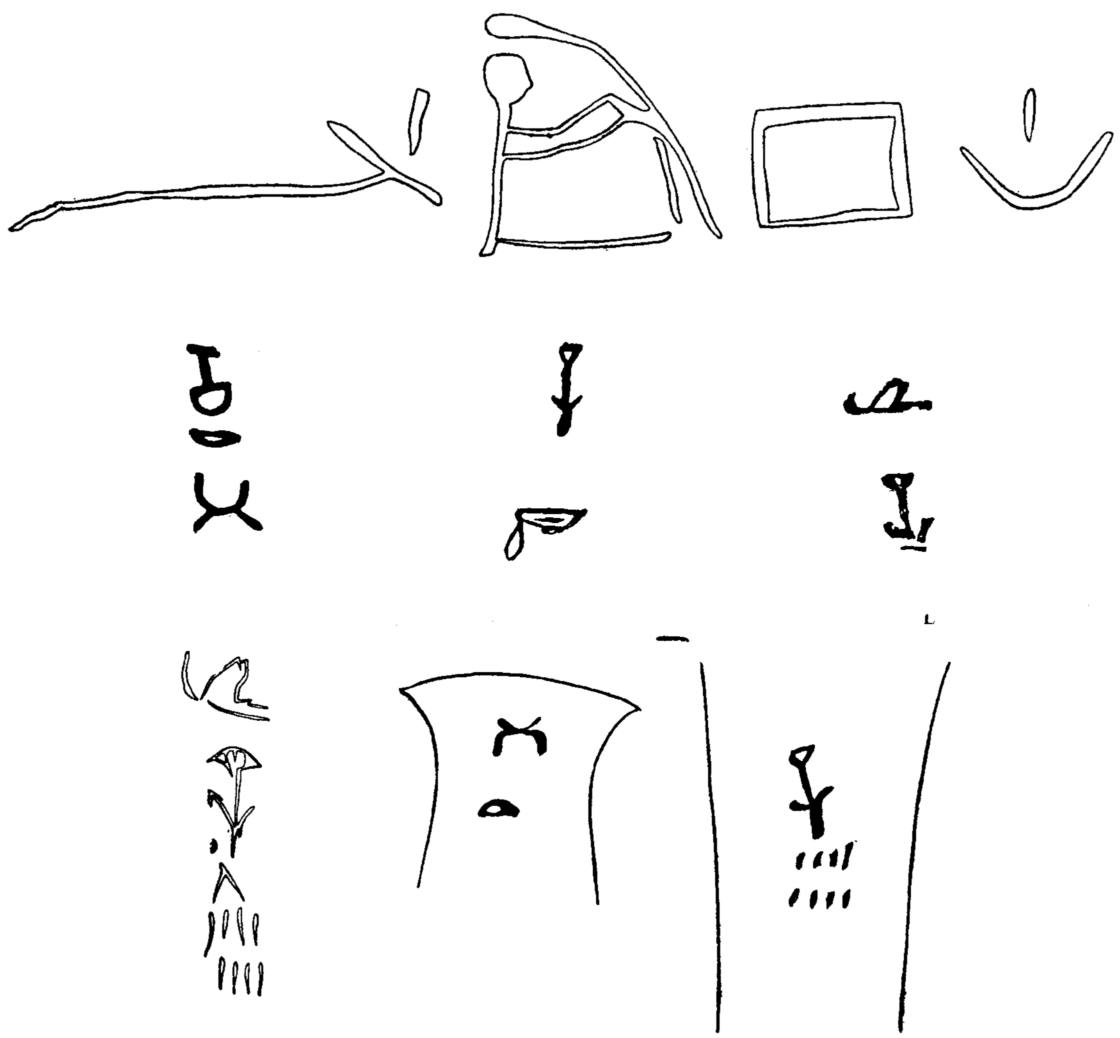

Fig. 3.—Samples of the signs on the wood

It is worthy to note that the building of the boat is a masterpiece of craftsmanship and shows the great skill of the Ancient Egyptians in ship-building and carpentry. Although the surfaces of most of the parts are quite smooth with regular curves, yet, it was taken into consideration that the opposite parts of the boat would be completely symmetrical.

Amongst the most important pieces which attract attention are the following :

Twelve oars Nos—2, 21, 22, 39, 40, 41, 42, 346–350, eleven of which are in a moderate state, and one (No. 350) is disintegrated. Each oar is of one piece composed of a cylindrical shaft and a wide pointed blade. The shaft extends in the blade in the form of a rib. At the end of two of these oars Nos. 39, 41 there is an incised arrow head on both sides.

Fifty-eight wooden poles Nos.—31,67,69,73,75,76,77,78,79,108,109,111,112,113,114, 115,116,117,122,123,124, 125, 126, 127, 128, 129, 130—135, 148, 150, 151, 152, 157, 158, 161, 162, 164, 177, 182, 189, with long cylindrical shafts and conical capitals having a slender projection on the top in the form of the sign ʿꜣ and somewhat similar to the present pole-tent (Pl. XIII, A).

Three cylindrical columns Nos. 71, 159, 160 of wood whose capitals are in the from of a bundle of 8 palm leaves under which there is a high relief representing symbolic ropes. On one of the leaves there is a copper staple. (Pl. XL, B).

Five doors two of which (Nos. 9, 61) are composed of longitudinal planks fixed together with side-dowls, having projecting pivots and a copper semicircular eye-bolt, and the planks of each door have 9 loose parallel bracing bars each of which is almost semicylindrical with tapering ends. On the back side of each bar of the door No. 9, there are strokes in black colour indicating their order on the door. Doors Nos. 43,59 are similar, but in between the bracing bars of each door, there is a bolt in the form of the hieroglphic sign —+— moving inside two copper staples. (Pl. XIV).

On the board No. 60 was found a rectangular piece of wood 11.5 cms. long, 4.5 cms. wide, 1.8 cms. high, containing 4 pegs of wood, one in each corner, having in its centre a copper rivet holding a wooden bolt latch insect representing an elater 14.5 cms. long (Pl. XIII, B.).

In addition to the wooden parts of the boat and the mats, ropes, etc, there were found on the floor of the pit a flint implement in the form of a knife (Pl. XV, A) and a piece of granite of no definite shape (Pl. XV, B).

The very fine traces of white colour on the surface of some pieces of the boat and the absence of any traces for the effect of water on the side parts of the boat, indicate that the boat had never been used on the Nile.

For a comparative study, Doctor Abd Moneim Abu Bakr, Professor of Archaeology, Cairo University, has recently given a lecture on "The Solar Boats" in the Egyptian

Geographical Society. He stated that " The model sun boats kept the same type and features during both the Old and the Middle Kingdoms, the most important characteristic of which are :

1.—The prow rises up and ends with a long stand, whilst the stern is a little bit curved.

2.—In the middle, there are certain columns and symbolic and vogue deities (Fig. 4).

FIG. 4.—The usual type of solar boats

Nothing of the kind was found amongst the pieces of the newly discovered boat.

After the preliminary reconstruction of the boat, by Mr. Ahmed Yousef, it was found that it was 43.40 m. long, 5.53 m. wide, and about 7.90 m. high and therefore longer, wider, and higher than the pit.

It is likely that after the complete reconstruction of the boat, and the lifting up of the western blocks covering the western pit, as well as after a thorough study of all the different contents of the two pits, it will be possible to know more about the function of these boats. Whether they were considered funeral boats used in some ceremonies for the burial of the king, or whether they were destined to be used by the king in the after world for making pilgrimage to certain sacred places like " Buto " or " Sais " these are questions for which we hope to have an answer by the end of the work.

So far we have only some of the boats near the First and Second Pyramids, but nothing of that kind was unearthed beside the Third Pyramid. We hope after the full investigation of the areas around the three Pyramids to discover other boats, the study of which may help in clearing the question about boats.

But it is evident that the mere discovery of such a huge boat of that remote date in this wonderful state of preservation of which no similar example we had before-is considered rightly a great discovery.

ZAKI NOUR
Sub-Director of the Inspectorates

List of Figures

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List of Plates

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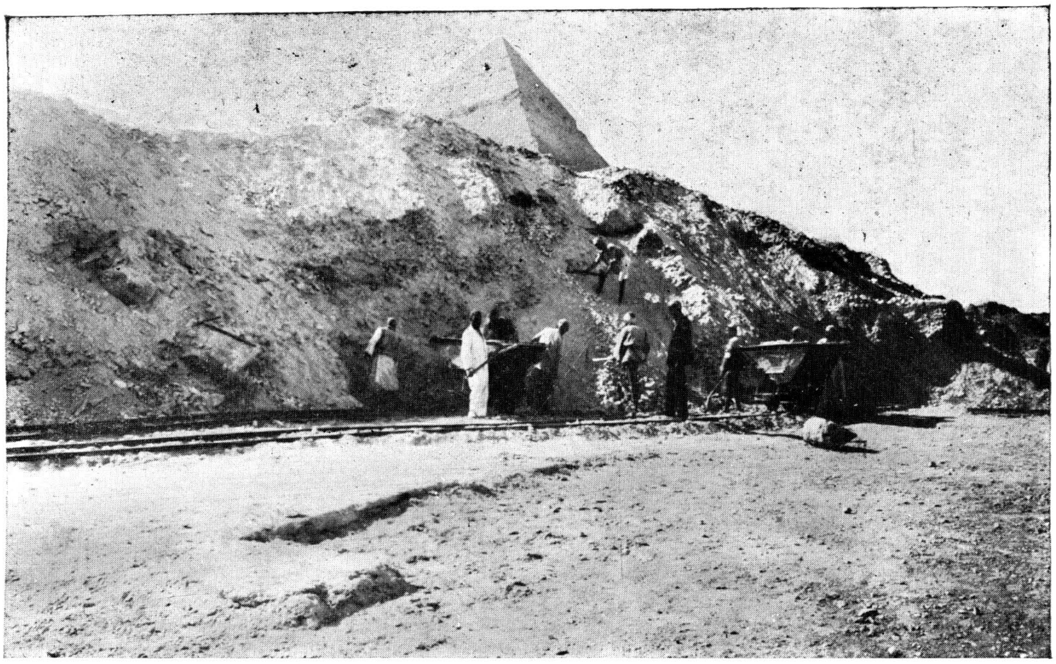
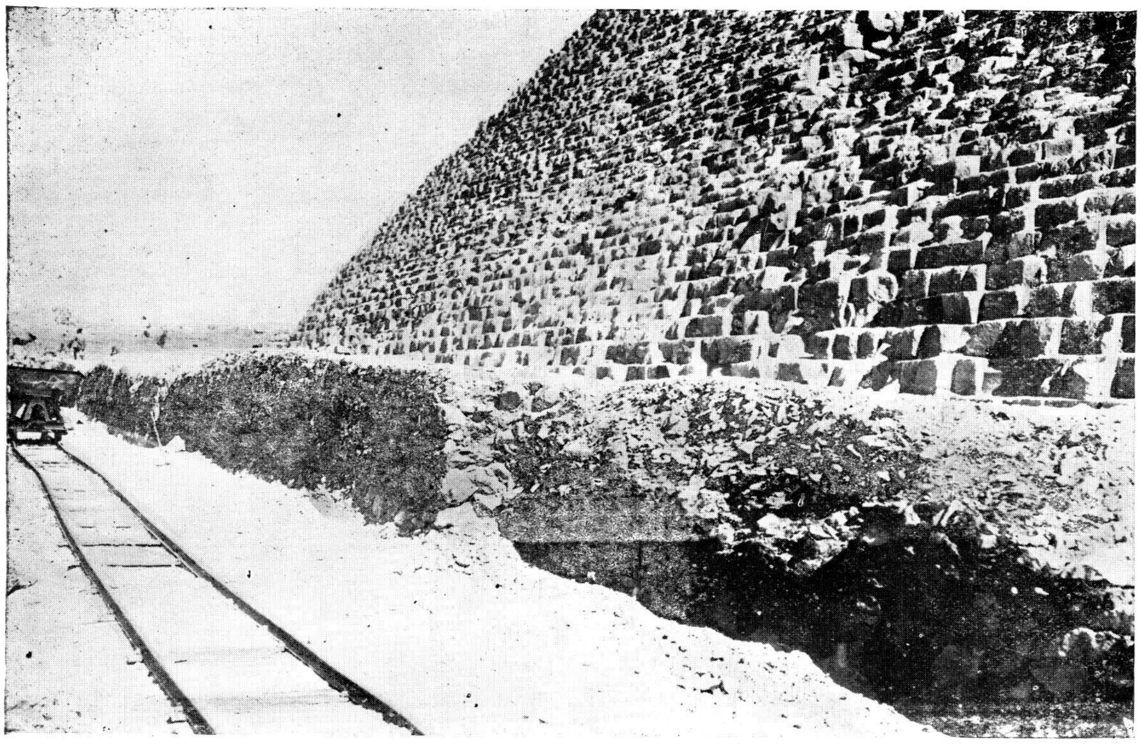


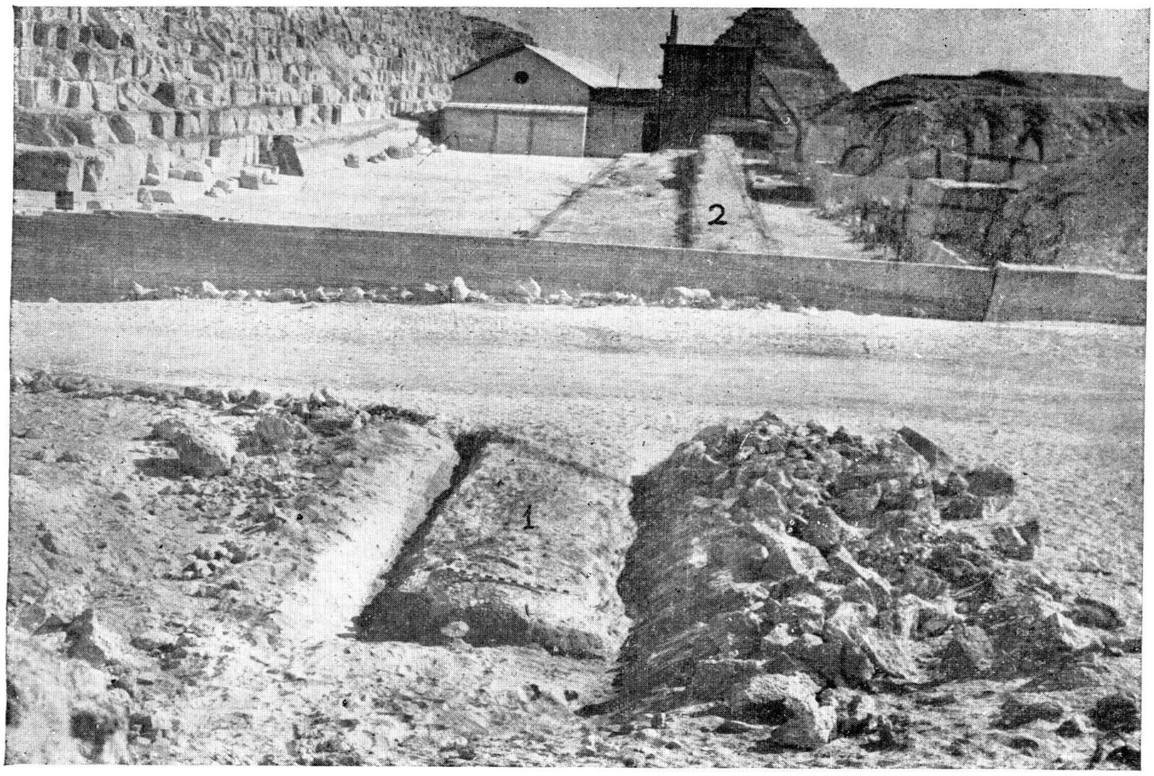
A.—Removal of the debris to the south of the Great Pyramid.

B.—Most of the debris removed.

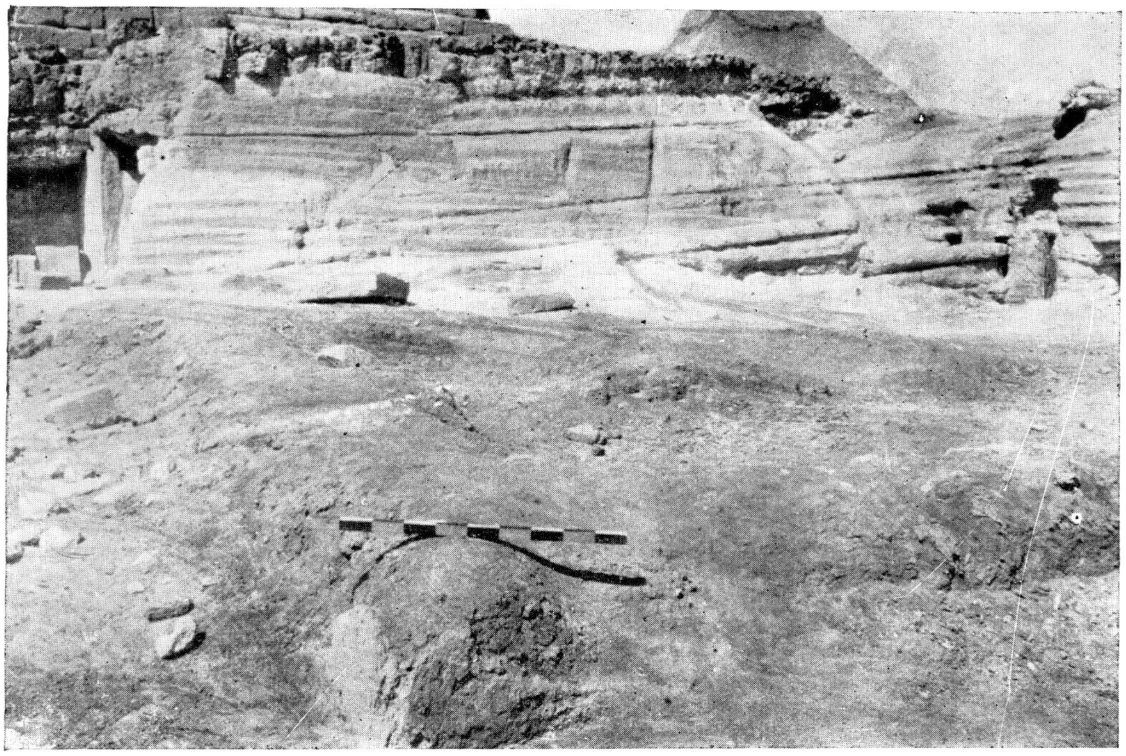


A.—Photograph showing the lighter colour of the stones of the Pyramid after the removal of the debris.

B.—The part of the enclosure wall that appeared to the south of the Great Pyramid



A.—Part of the western enclosure wall (1) near its meeting point with the southern wall (2).

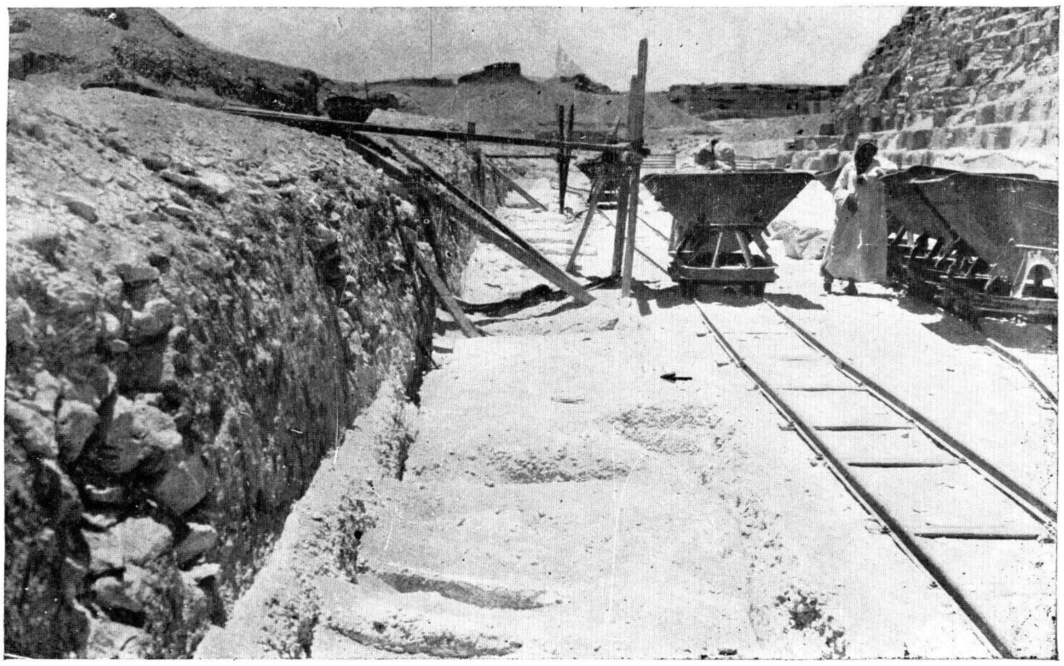


B.—The Fourth Pyramid and beside it buildings of mud-bricks coated with white plaster.

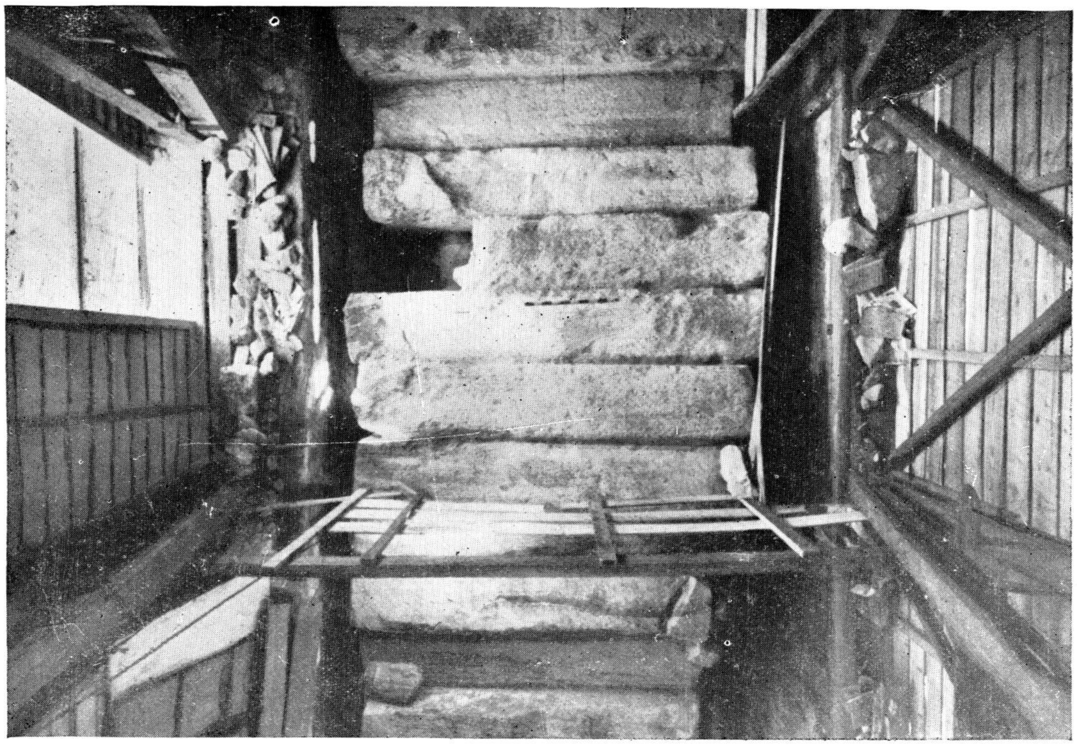
A.—Parts of the inclined walls of the causeway of the Second Pyramid at Giza.

B.—Part of the southern wall showing the junctions denoting the building of the wall by several groups of labourers.

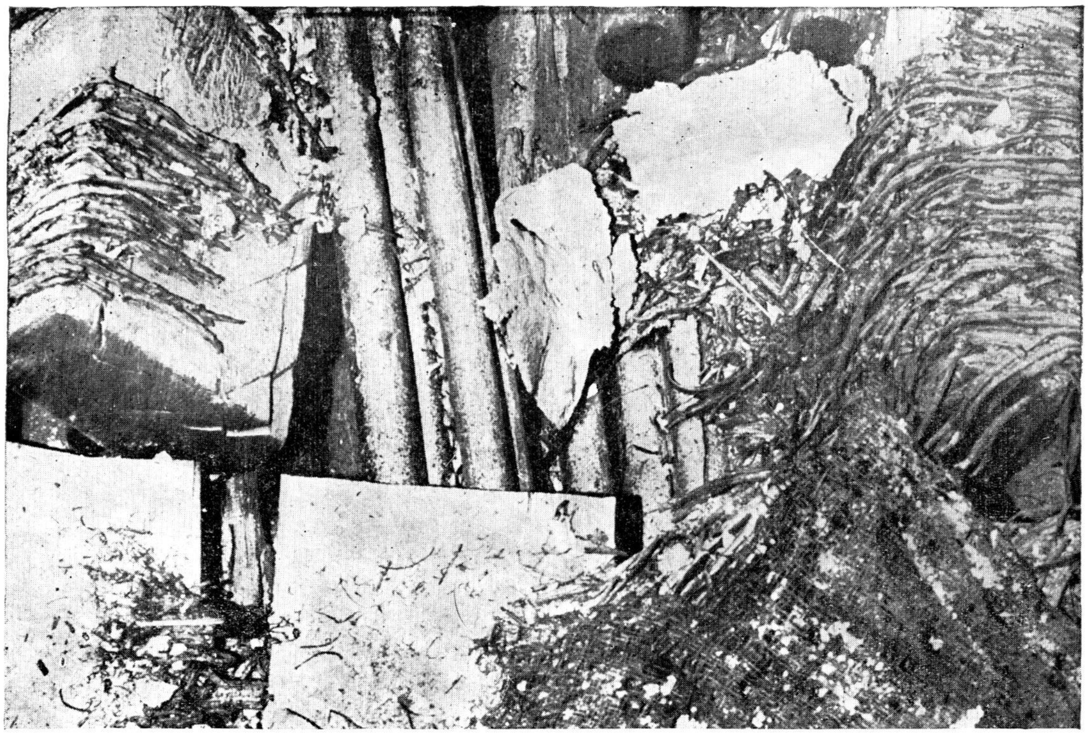
A.—The junction cased with mud plaster.



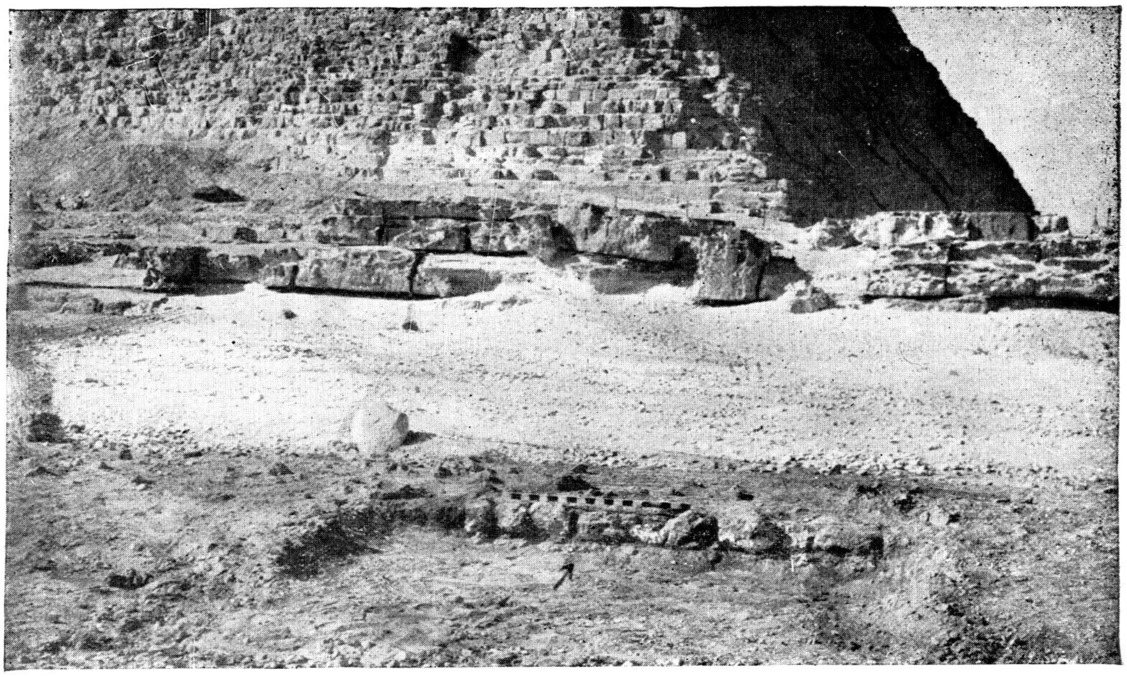
B.—The partition between the two groups of blocks.



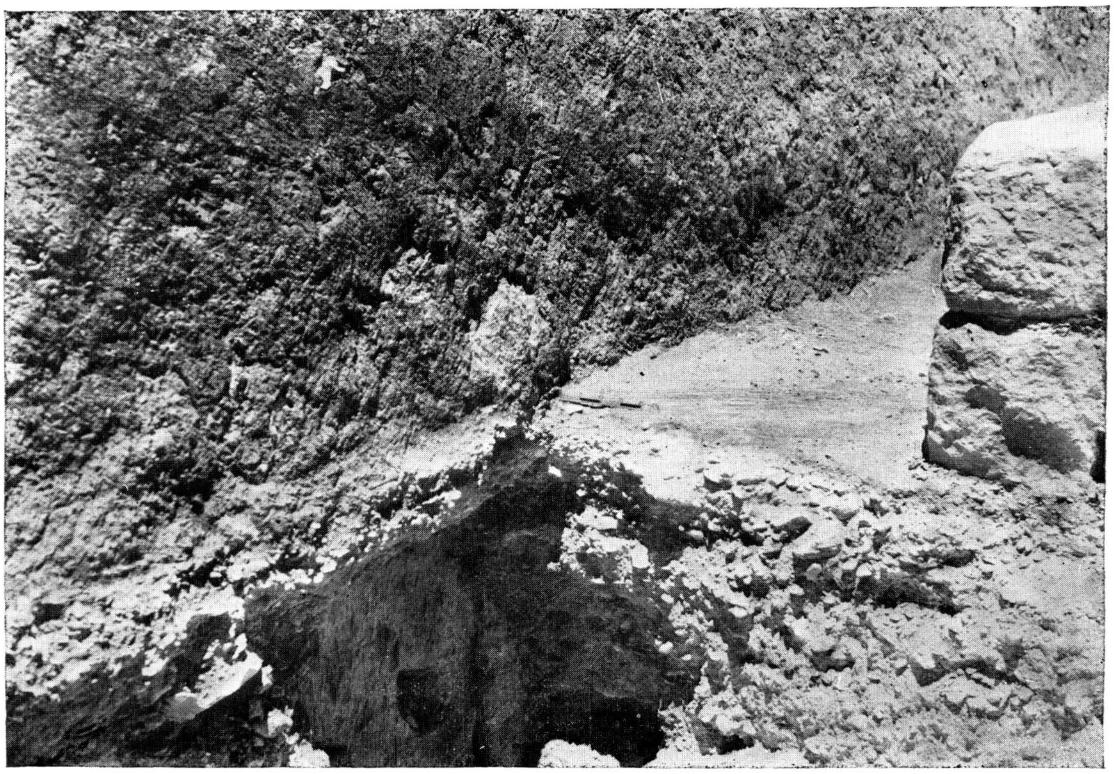
A.—The block through which the hole was made.



B.—Part of the surface of the boat covered with different kinds of matting.

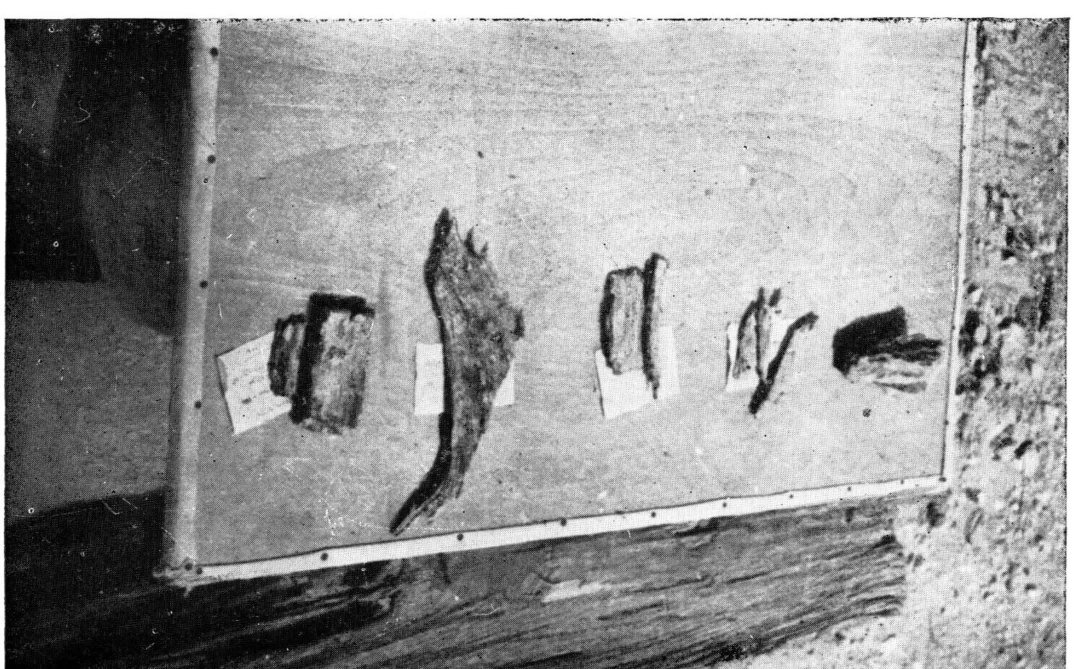


A.—Remains of the eastern enclosure wall of the Second Pyramid at Giza.



B.—Mud plaster coating the southern wall.

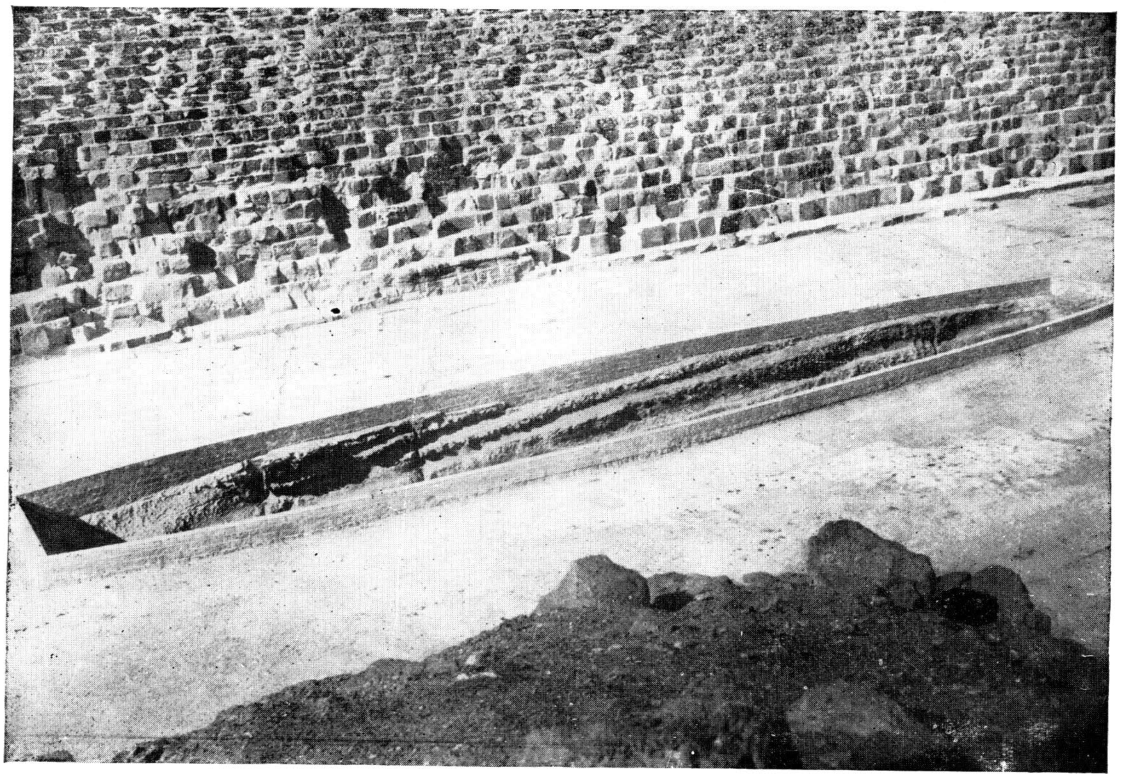
A.—Scraps of wood as found in the compressed ground.



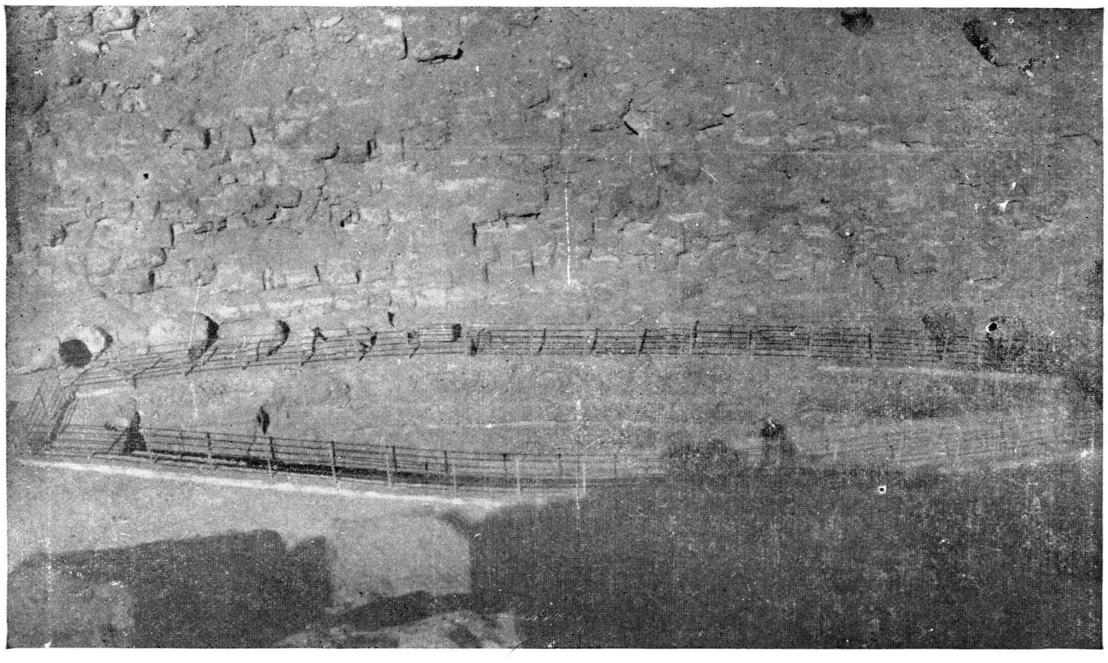
B.—Some scraps of the wood which were found in the compressed ground.

A.—The semicircular hole and the three other holes found carved in the rock to the east of the eastern pit.

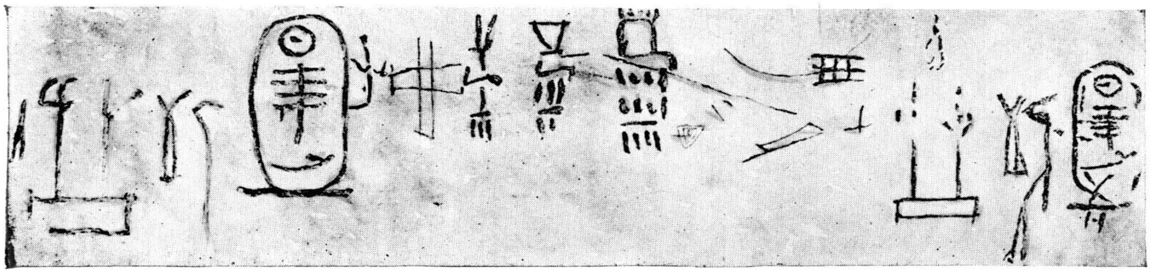
B.—The rectangular hole found carved in the rock to the west of the western pit.



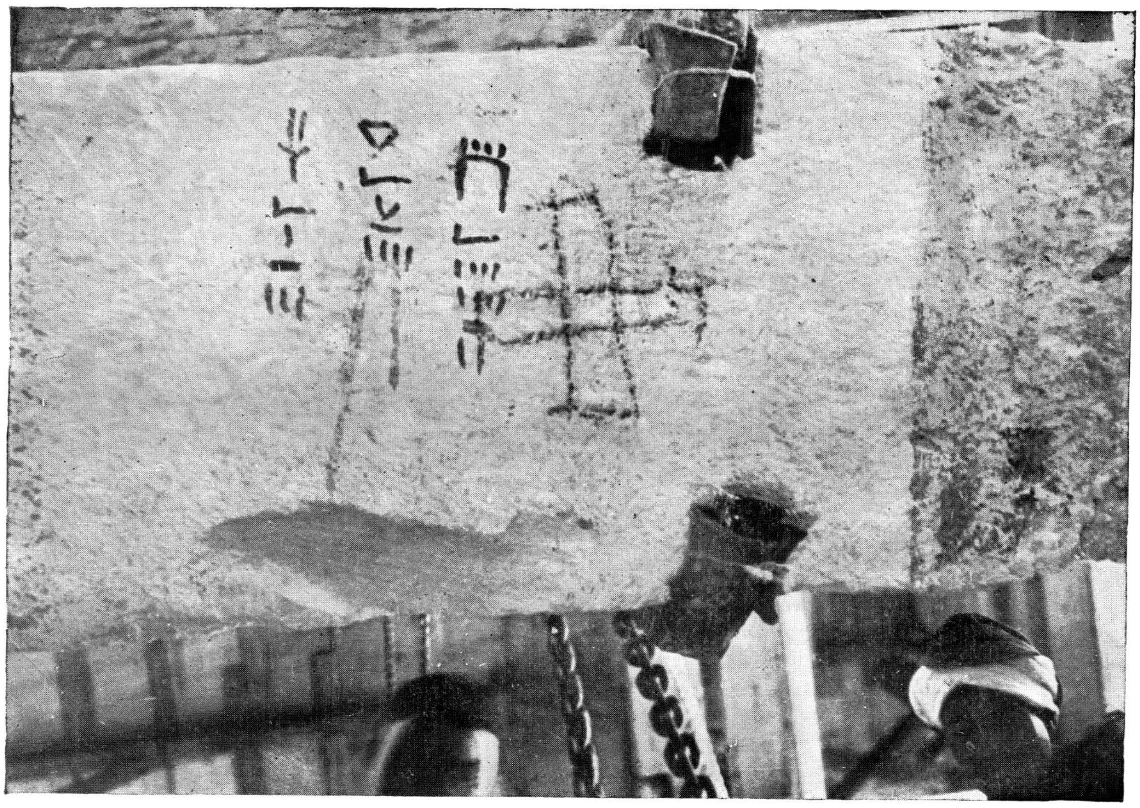
A.—One of the pits cut in the rock in the form of a boat to the east of the Great Pyramid.



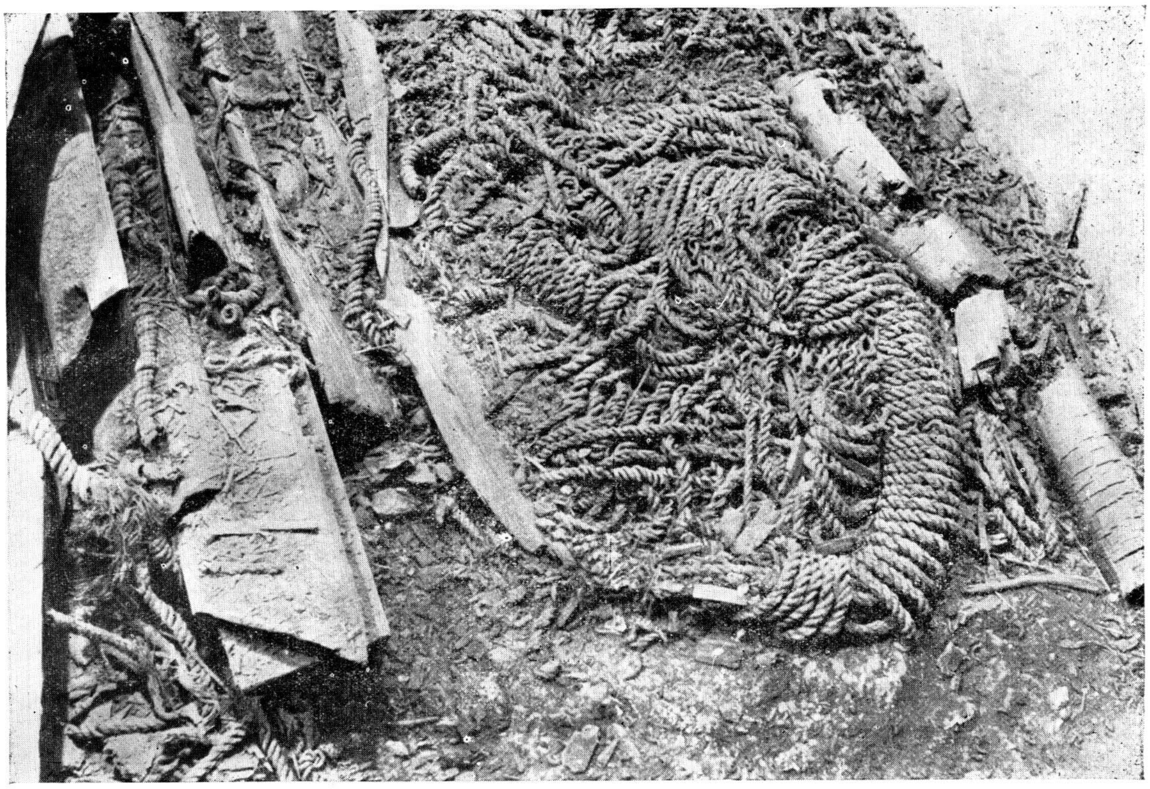
B.—The pit cut in the form of a boat between the Pyramids of Cheops' wives
to the east of his Pyramid.



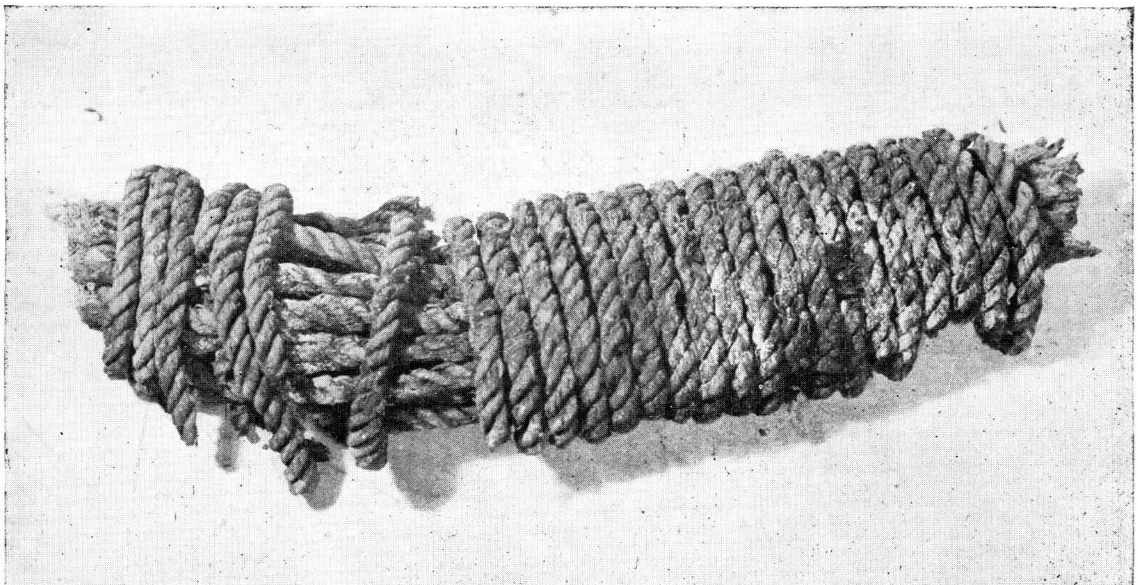
A.—Quarry marks inocribed on the lower surface of block No. 20



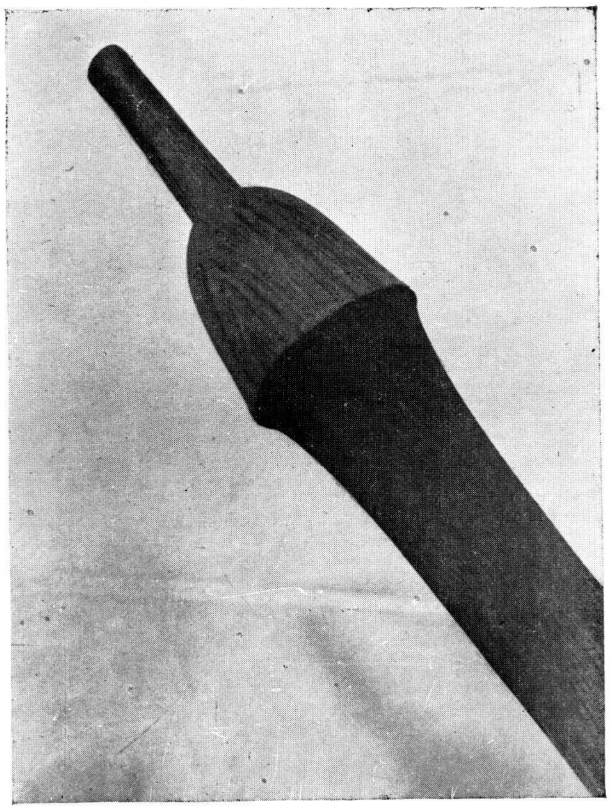
B.—Quarry marks found on the lower surface of one of the blocks.



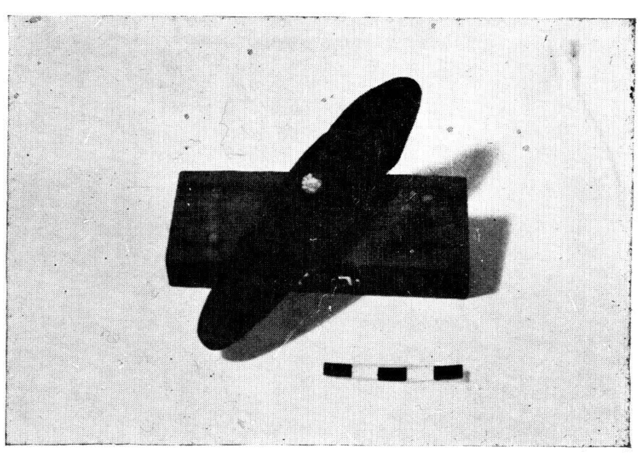
A.—One of the many collections of ropes found in the boat containing some knots.



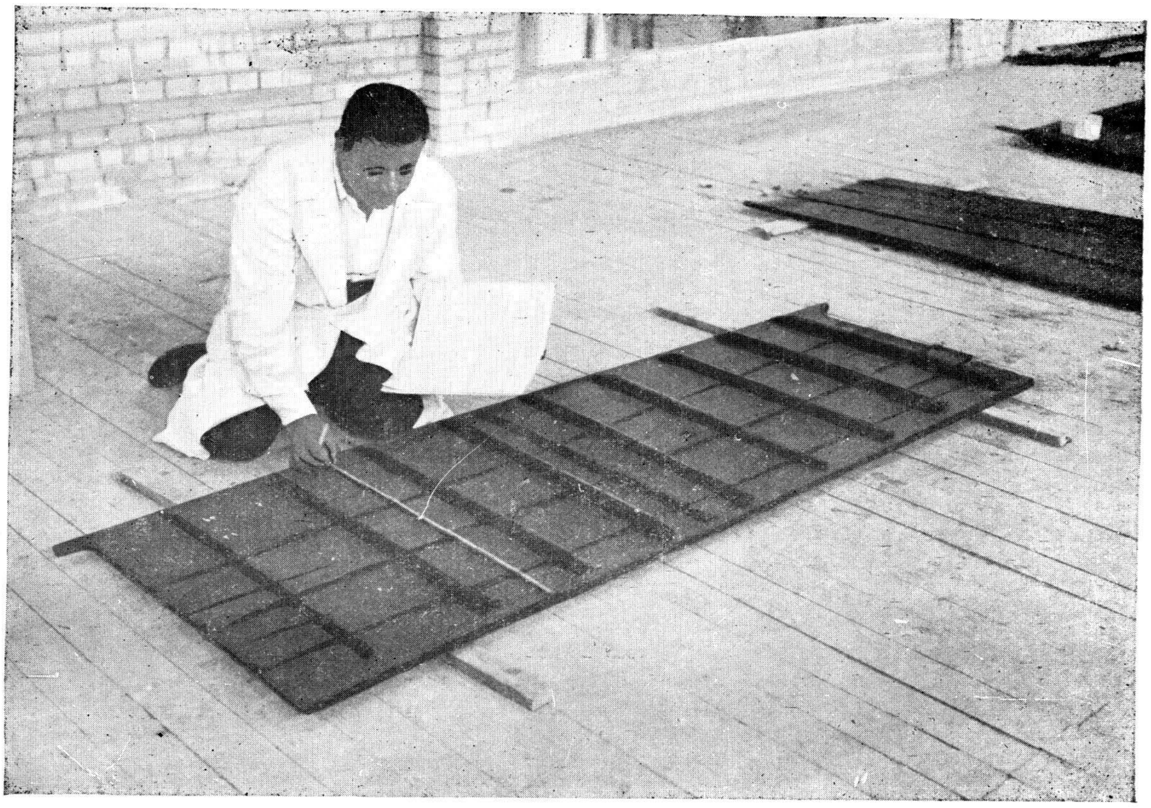
B.—One of the knots enlarged.



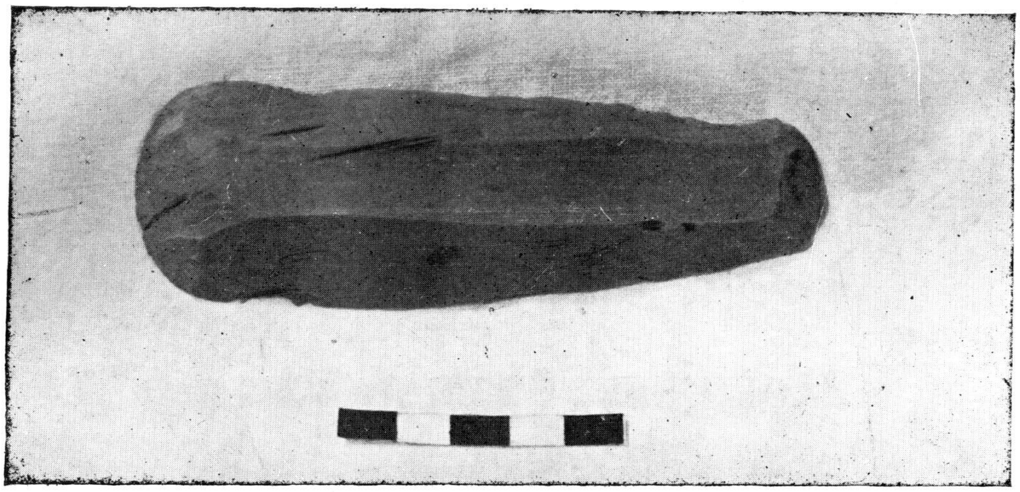
A.—Wooden pole.



B.—Wooden latch in the form of an elater.



Wooden door with a bolt.



A.—A flint implement in the form of a knife.

B.—A piece of black granite of no definite shape.

REPORT

ON

THE ENGINEERING WORKS

IN

THE NEWLY DISCOVERED BOAT

BY

MOHAMMAD SALAH OSMAN

INTRODUCTION

The engineering works in the pyramids area at Giza in 1953 involved clearing the southern part around Cheop's Pyramid where there was a big heap of debris blocking the space between the southern side of that Pyramid and the group of mastabas behind it. Fig. 5 is a cross section showing the position of the heap between the Great Pyramid and the group of mastabas.

The removal of this heap of debris lead to the discovery of a wall built of small pieces of limestone and clay running parallel to the southern side of the Great Pyramid and about 18.50 m. far from it. Its width is about 2.5 m. but the height is not regular (Pl. XVI, A).

Under this wall appeared the outlines of two groups of limestone blocks, one of which is towards the east and composed of 41 blocks occupying a length of 32.50 m. and the other group is towards the west and composed of 40 blocks occupying a length of 32.70 m. The two groups are separated by a partition 3.35 m. long from the rocky ground, the mid point of which lies on the axis of the Great Pyramid. Pls. XVI, B and XVII, A show the visible part of the blocks underneath the wall. Fig. 6 shows a plan for the two groups of limestone blocks with respect to the axis of the Great Pyramid.

A hole was made in the 22nd block in the eastern group and it was found that the limestone blocks covered a rectangular pit containing the parts of a large wooden boat. A plan was therefore made to erect a wooden shelter over the whole eastern group of blocks. This shelter was designed to be strong enough for carrying the blocks when removed. The part of the wall above the eastern group was removed after registerning it by photographs and engineering drawings, then the blocks were lifted up. Pl. XXVI shows a general elevation of the middle part of the wall and detailed drawings for portions of that wall.

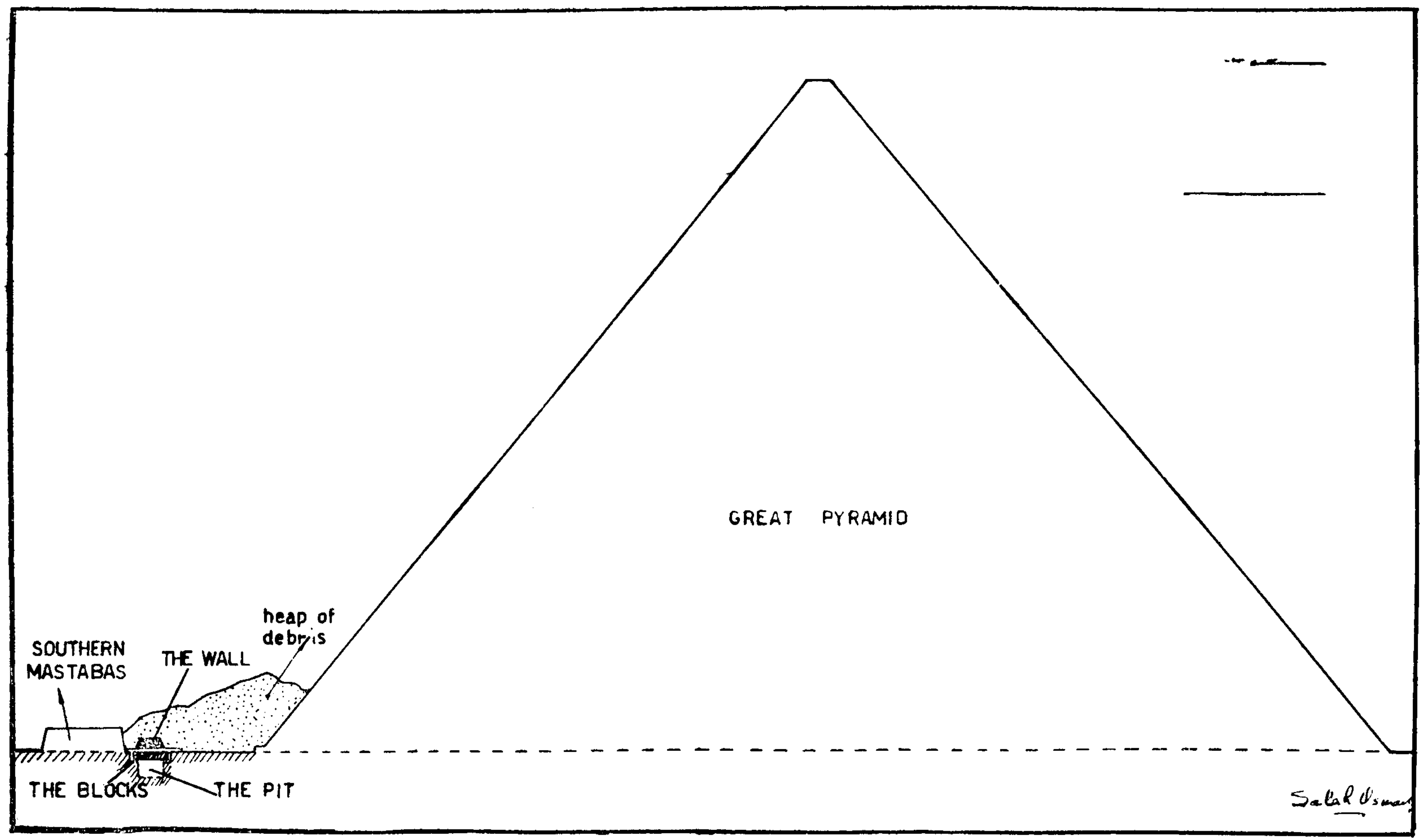


FIG. 5.—Transverse cross section showing the position of the heap of debris between Cheops Pyramid and the group of mastabas.

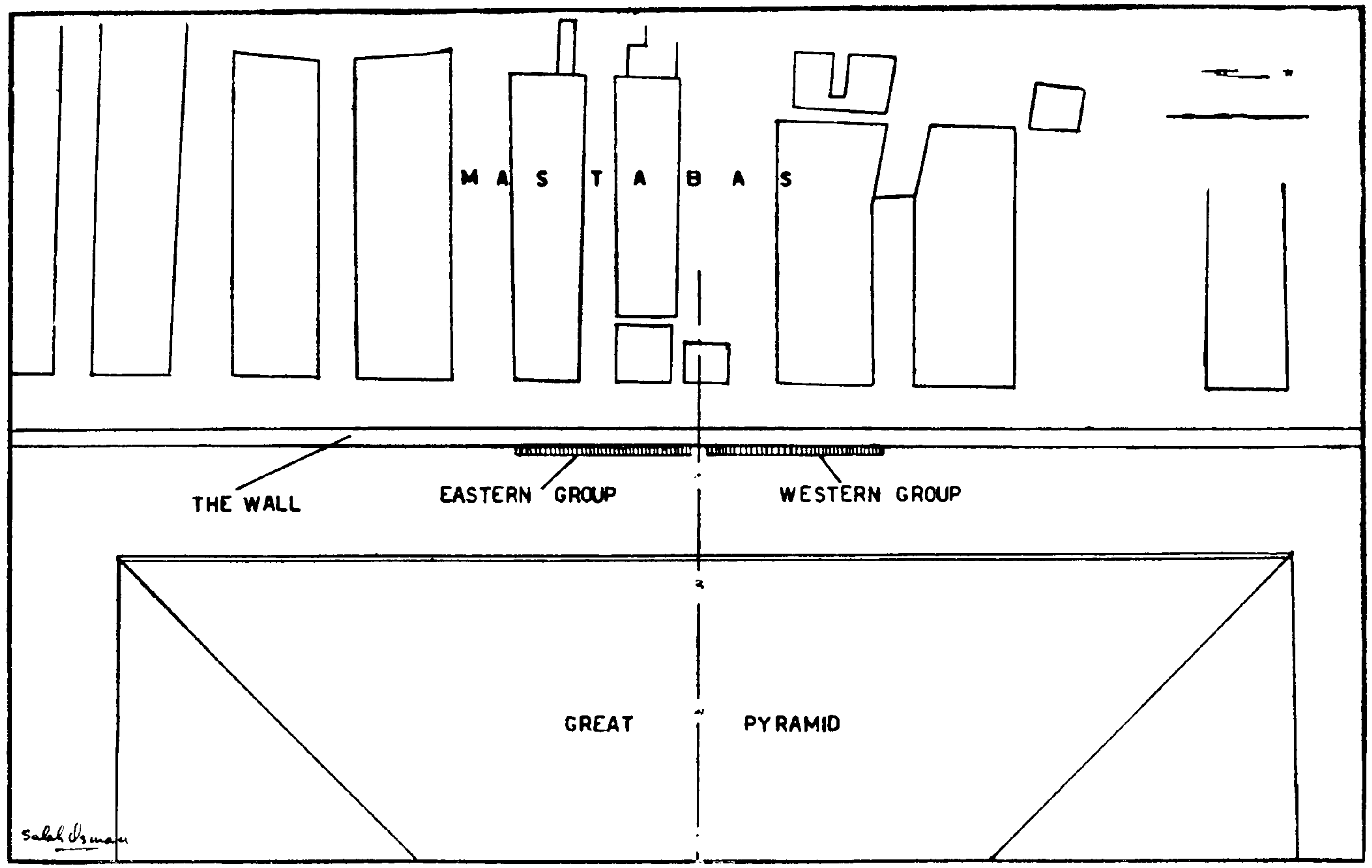


Fig. 6.—Site plan for the wall showing the two groups of blocks.

Erection of the Shelter

The shelter was erected with a dolly truck moving rails fixed along its upper part.

The calculation was based on the weight of the largest block. The block which appeared to possess the greatest bulk was measured and found to be $4.80 \times 1.60 \times 0.85$ m. *i. e.* **6.528 m³**. The specific gravity of the limestone of the block was determined in the chemical laboratory of the Department and found to be 2.45.

The weight of the heaviest block is therefore $\frac{6{,}528{,}000 \times 2.45}{1{,}000{,}000} = 15.99$ tons. Adding 50 % as factor of safety, the load on which the design will be based must be about 24 tons.

Applying the universal formula $P = 3.12\ d^2 + 0.27$ in which P is the load in tons, d is the diameter of the rope in inches, on a Manila hemp rope 1 1/2 inch thick, we find out that the one turn of such a rope can carry a load of 7.3 tons. So, by using 2 cranes each provided with such a rope to be wound twice round the block, we can lift a load of 30 tons which is more than our maximum load. Two hand operated gear cranes each of 20 tons capacity hanging from the movable dolly truck were used in the operation.

The skeleton of the shelter was made of timber logs 30×30, 30×20 and 12.5×10 cm. in cross section. The roof was made of wood covered with cloth impregnated with tar. The sides were sheeted except the northern side facing the Great Pyramid which was composed of equal spans of unfixed sheeted frames.

Inside the shelter, on each side of the upper part was constructed a timber purlin 30×30 cm. on which a rail was fixed. The dolly truck moving on these rails was constructed on 1 3/8 inch axles which revolved in roller bearing stuffing boxes, the chassis consisted in the main of two 30×30 cm. timbers bolted athwart the chassis at right angles to the axles, they, in turn, supporting two cross timbers of equal dimensions running parallel to the axles. This method reduces the area of downthrust strain to a minimum and produces a reasonable safety factor for loading. Breaking point of the 1 3/8 inch axles far exceeds my expected stress. From the upper cross timbers the two 20 tons cranes were hanging by turns of the same 1 1/2 inch rope. Two steel pairs of pickers were made of 7×7 cm. steel bars and each pair was attached to the lower hook of each crane. The whole truck moved easily on the rail between the first and last blocks. Pl. XVII, B shows the erection of the skeleton of the shelter above the wall, Pl. XXVII shows a longitudinal cross section for the shelter and Pl. XXVIII shows a transverse cross section of the shelter with the truck. Pl. XVIII, A shows the shelter from outside after being finished.

The Limestone Blocks under the Wall

After removing this part of the wall, the limestone blocks appeared in their real shape, they were covered with a hard layer of compressed ground 40 cm. thick. Fig. 7 shows the formation of the wall and the hard layer of compressed ground. After removing this layer, the 41 blocks forming the eastern group were completely clear.

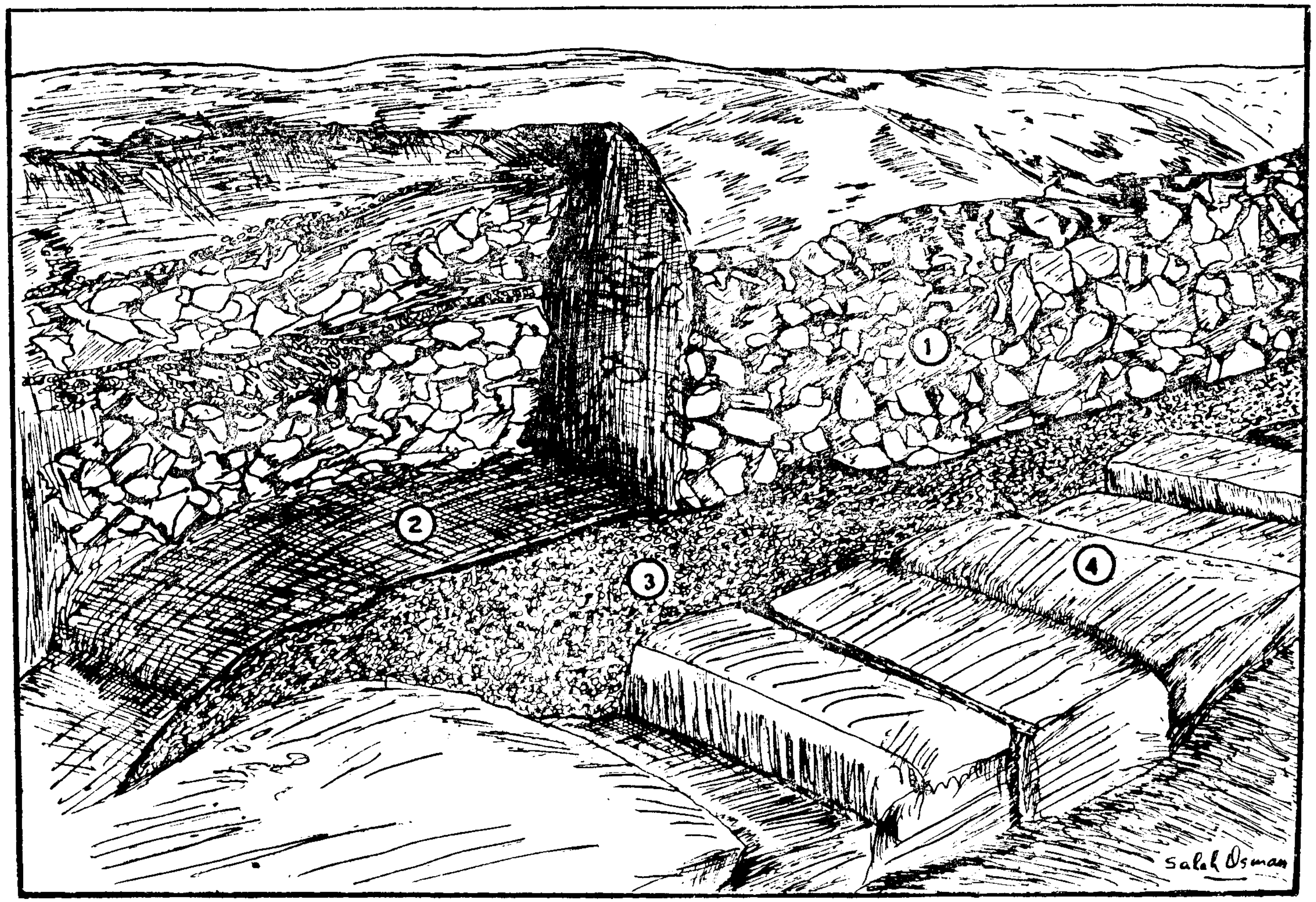


Fig. 7.—The construction of the wall

(1) The Wall
(2) Layer of Mud.
(3) Layer of hard Mortar.
(4) The Blocks.

Pl. XVIII, B shows this group. By studying the position of this group, the following remarks were made :—

(*a*) The blocks were placed side by side without any space between the adjacent blocks. The spaces between the extremities of each block and the vertical edge of the pit were filled with small pieces of stone (shutters).

(*b*) The top surface of these blocks was not regular as some of the blocks were higher than the others, the difference ranged between 2 and 10 cm.

(*c*) Some cursive hieroglyphic inscriptions were written in red colour on the upper surface of some blocks. These inscriptions were duly recorded.

(*d*) It was noticed that the last block from the western end was not the end of the pit. The pit was closed after that with five small stones varying in size and were arranged in a special way to serve as key-stones to the group. It was concluded that the blocks were placed on the pit starting from the eastern end and ending by the last block together with the key-stones in the western end. Pl. XXIX shows a longitudinal section of the pit covered with the group of blocks, the small pieces of stone at the extremities of each block and the group of key-stones at the western end of the pit.

Lifting up the Blocks

On the 23rd November 1954, the work started by lifting up the five keystones thus we had enough space which enabled us to separate block No. 1 from the one next to it. Pl. XIX, A shows the space previously occupied by the key-stones. The small pieces of stones (shutters) filling the space between the extremities of the block and the vertical edge of the pit were then removed. Wooden wedges were placed between block No. 1 and block No. 2 at the top. By blowing gently on these wedges, the two blocks were separated. By using steel levers, block No. 1 was shifted west-wards enough to pass the rope round it. Pieces of thick felt were placed between the block and the lever during the operation. Since there was not enough space between the block and the western edge of the pit, we could not use the pickers, so, we just used the 1 1/2 inch rope and the two cranes which were operated simultaniously to assure the equilibrium of the block during lifting it. Pl. XIX, B shows the first block while being lifted. The operation continued till the bottom surface of the block reached the top surface of the other blocks where longitudinal timber logs 20 × 20 cms. were placed with wooden rollers 12 cms. in diameter on them. The block was pulled on them outside the shelter. A thick layer of felt was placed between the block and the rollers while pulling it. Pl. XX, A shows the block while being rested on the rollers inside the shelter. Pl. XX, B shows an attempt to get the block outside the shelter. Pl. XXI, A shows the block after being pulled outside.

The director of the chemical laboratory wanted to keep the atmosphere inside the pit as constant as possible, lest the contents in the pit might be badly effected after being completely isolated from the outside atmosphere for about 4700 years. So, the removed block was replaced by a timber board having the same dimensions as the bottom surface of the block. This was done also for the rest of the blocks. The boards were to be lifted only whenever needed. Fig. 8 illustrates the purpose of these boards.

A part of the pit being uncovered, we had enough space to be able to use the pickers in lifting block No. 2 and the following procedure was adopted :—

1.—The stone shutters were removed from both extremities of the block.

2.—One jaw of the pickers was placed under the block from the western side, then using the two cranes together with the steel levers between this block and the one next to it, the block was lifted slightly thus separated and moved west-wards enough space to pass the other jaw of the pickers.

3.—The truck carrying the cranes was moved till it became just above the block. Each of the two pickers was fixed to one end of the block, then the block was lifted up by using the two cranes simultaneously. Fig. 9 A shows how the block was separated from the one next to it by using the pickers and levers. Fig. 9 B shows the same block after being shifted and the two pickers around it. Pl. XXI, B shows the same block when it reached the top level before being placed on the rollers.

It was noticed that the rate of lifting up of the block which weighed about 16 tons was 6 cms. per minute.

The same procedure was followed in lifting up the other blocks till block No. 17. Coming to block No. 18, its dimensions were found to be abnormal. Having a width of 47 cms. only, we could not use the pickers in lifting it as well as it was not safe and even difficult to pull it outside the shelter on the rollers in the normal vertical position. Thus after separating this block and shifting it slightly westwards in the same way as the others blocks, another procedure was followed in lifting it. It was turned on its western side and tied with ropes at both ends, then lifted up by the cranes only, without the pickers till it rested on the rollers then pulled outside the shelter. We proceeded to lift the rest of the blocks till No. 41 without any obstacle or abnormal case aside from the following :—

1.—It was noticed that the shutters of block No. 8 at the southern side reached the top level of the block, a case which did not happen in all the other blocks, which made it very difficult to remove them and we were forced to leave some of them till the block itself was separated from block No. 9 and lifted. We found also a circular cavity 16 cm. in diameter and 18 cm. deep at the middle of the upper surface of this block.

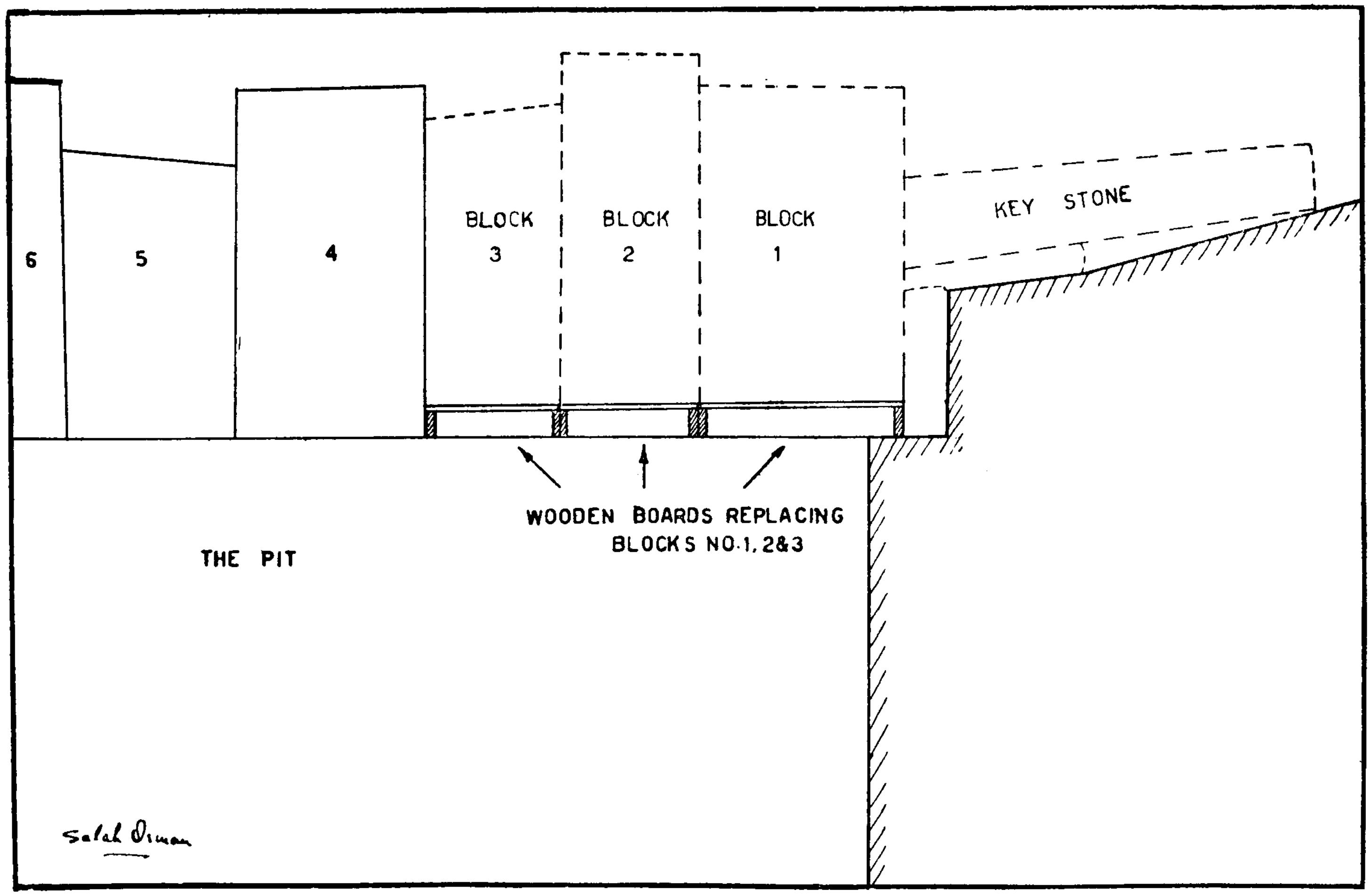
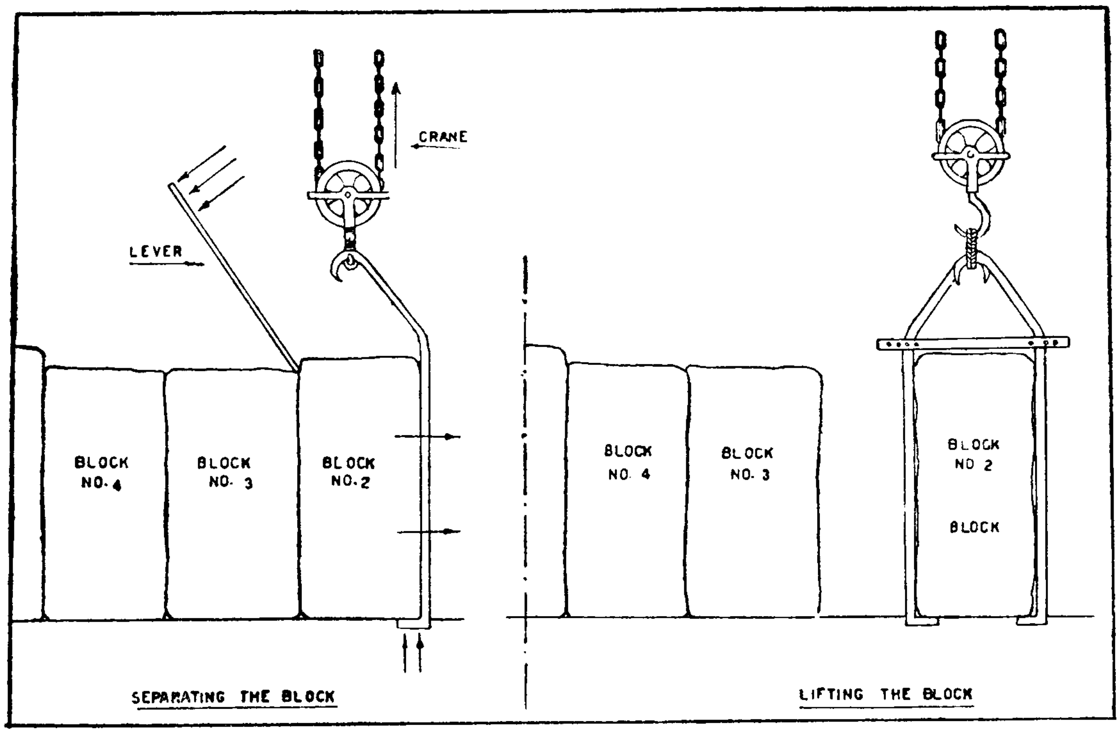


FIG. 8.—The wooden boards replacing the removed blocks.

2.—When lifting block No. 39, a longitudinal crack was noticed about the middle of its breadth. Since it was a serious crack, precautions were taken for the safety of the block itself and of the workers during pulling it outwards. This was maintained by making a longitudinal double bond with two pieces of 4 × 5 inches lumber fixed by long screw bolts and nuts.



A B

Fig. 9.—(*A*) Process of separating the block from the one next to it.
(*B*) The use of the pickers in lifting the block.

Further Observations on the Blocks and the Pit

In the course of lifting the blocks up and moving them outside the shelter, the following observations were recorded :—

1.—A layer of fine sand sometimes mixed with clay was found between the blocks and the horizontal edge of the pit at its support. it is most probable that this layer was applied to slide easily every block in its right place.

2.—In some blocks such as Nos. 7 and 8 some natural defects in the shape of big holes were noticed in the surfaces of the blocks. The ancients filled these holes with a sort of mortar made of red gypsum. Pl XXII, A shows block No. 8 in the western surface of which appears the mentioned mortar. The upper western edge of block No. 24 was broken along the whole length of the block and was treated in the same way by the ancients to restore its original shape.

3.—Block No. 13 was characterised by an outstretching part on the top of it southern side.

4.—The presence of holes and openings in a repeated way in certain places of each block. For example in block No. 5. there are 2 semi-circular openings in the lower edge of its western side near the extremities. In the bottom surface at the extremities, there are 2 semi-ellipsoidal openings. In the northern and southern sides there is a square hole about 3-6 cms. deep. All these holes and openings were found repeated in the same way in all the blocks but the order changed in some of them. Thus, in blocks No. 32 and 36 two other semicircular openings are found in the upper edge of the western side. In block No. 35, one opening is found in the upper edge of the western side to the north, besides the other 2 openings in the lower edge. Also two square holes beside each other instead of one are carved in the southern side of blocks Nos. 1 and 27. These two holes are above each other in block No. 2. In block No. 31, these two holes are beside each other in both southern and northern sides. Pl. XXX shows block No. 5 mentioned before, in which appear the two semi-ellipsoidal openings near the extremities in the lower surface, and the two semi-circular openings at the extremities of the lower edge of the western surface. In the southern and northern surfaces appears the square hole at the upper part. Pl. XXII, B shows one of the extremities of the lower surface of that block in which there is the semi-ellipsoidal opening. Pl. XXIII, A shows the northern surface of the same block in which there is the square hole. Pl. XXIII, B shows one of the odd cases in which there are two square holes instead of one. It is most probable that these openings and holes were used in lifting the blocks and adjusting them in their places.

5.—Each block was stuck to the next to it with a kind of pure liquid gypsum mortar which was found in the form of a very thin layer between each two blocks. In some blocks the traces of sculpturing were examined microscopically and in these examinations copper particles were found, from which we can conclude that some copper tools were used. (see the scientific report).

6.—Inscriptions, mostly in black or red colour, were noticed on the lower surfaces and the sides of many blocks.

7.—On the two horizontal ledges along the northern and southern sides of the pit there were found circular shallow holes at the support of each block. In the top of the eastern vertical edge of the pit to which the block No. 41 was fixed two square openings 10 × 15 cms. and 10 cms. deep were found. Outside the pit towards the east several semi-circular and square holes varying in depth were found. It is most probable that these holes together with those in the pit were used in the operation of levering and adjusting the blocks in their places. Pl. XXIV, A shows the openings and holes of the pit. Pl. XXIV, B shows the holes outside the pit.

Pl. XXV, shows the group of blocks outside the shelter, and in the right end of the picture appears the group of keystones.

On 28th January 1955, the operation of removing all the blocks outside the shelter was completed and the wooden parts of the boat were ready to be lifted from the pit for treatment and rebuilding the boat.

Engineer
M. Salaḥ Osman

List of Figures

List of Plates

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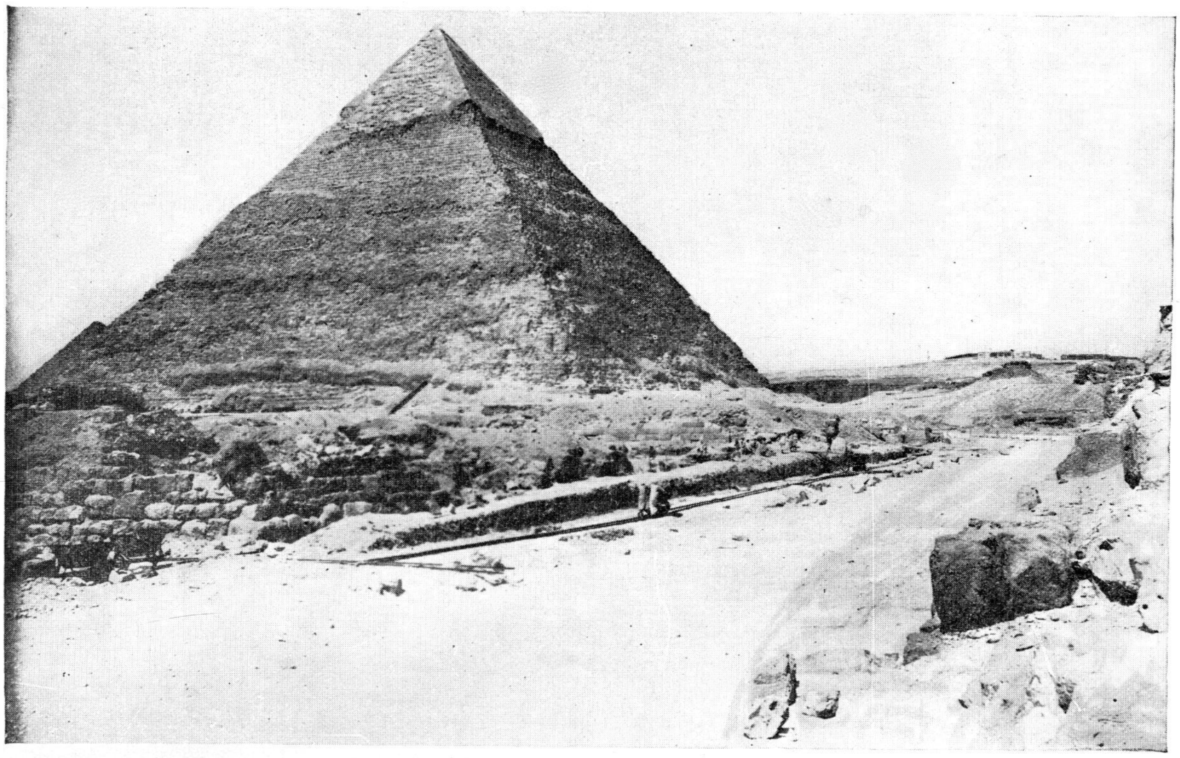
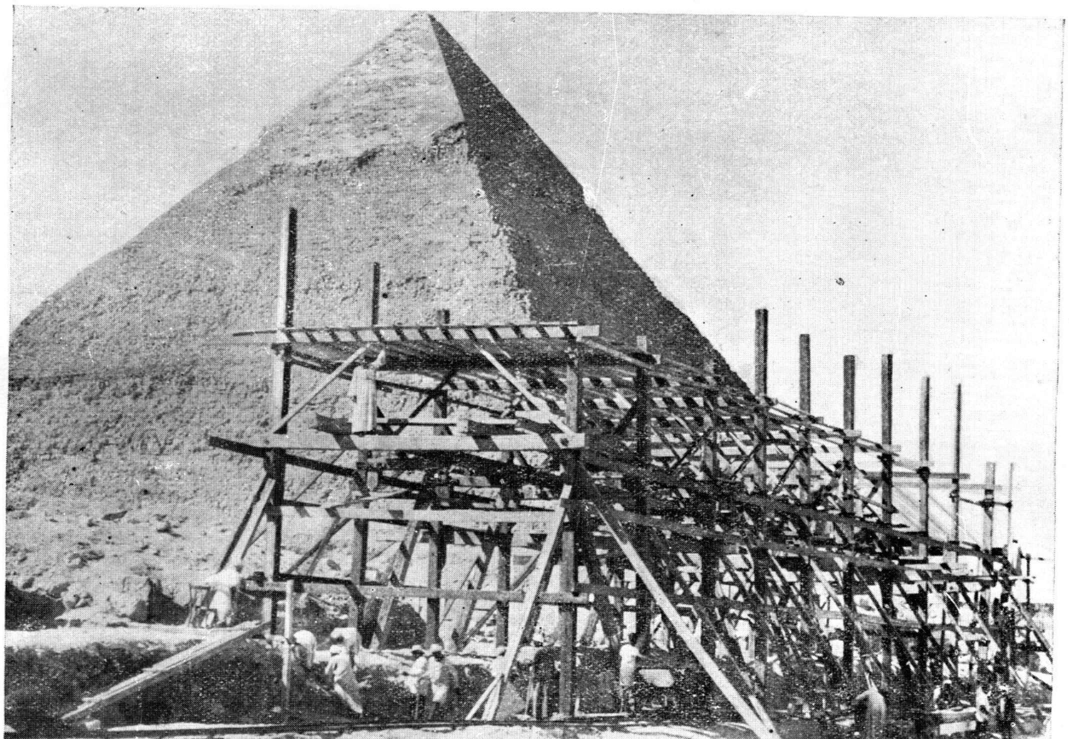


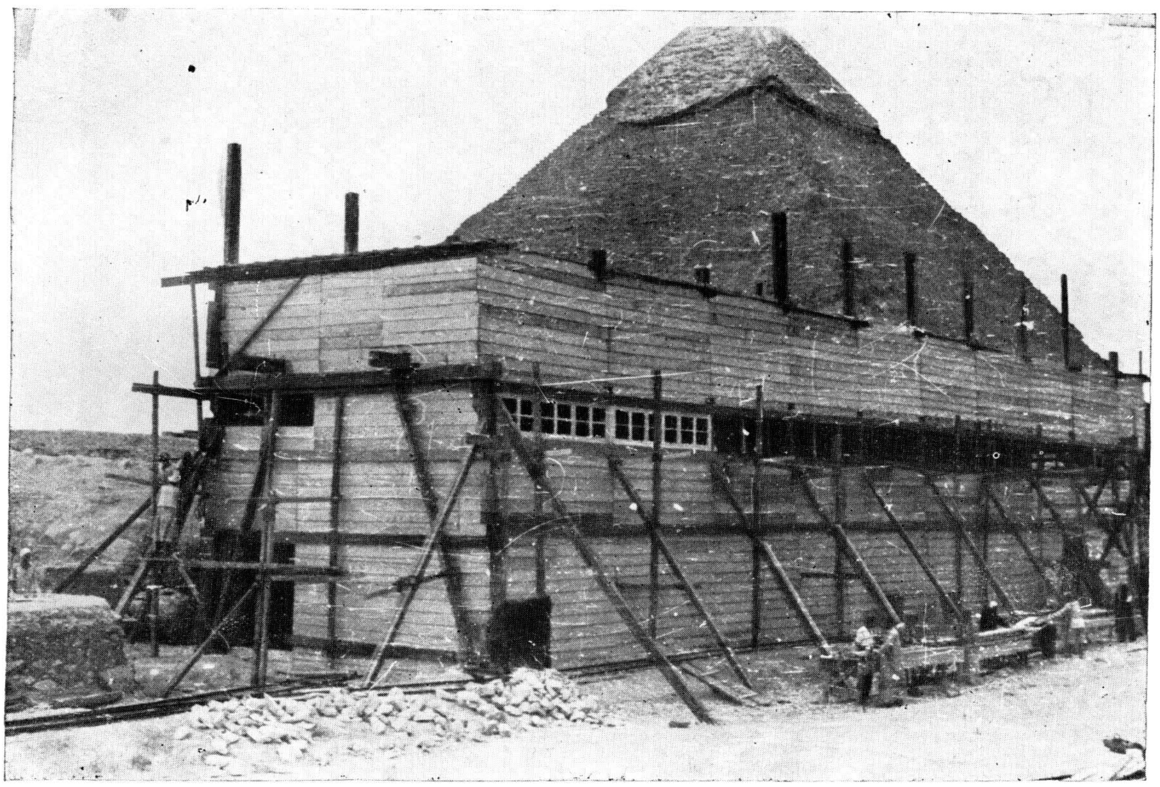
A.—General view of the wall with respect to the Pyramid.

B.—The visible part of the blocks underneath the wall.

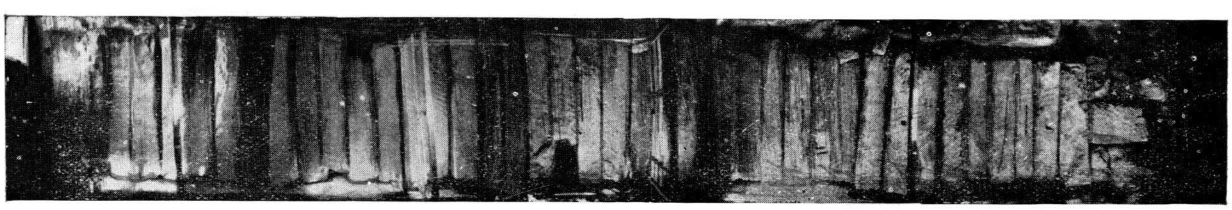
A.—Part of the wall over the compressed ground and the blocks.



B.—Erecting the skeleton of the shelter.

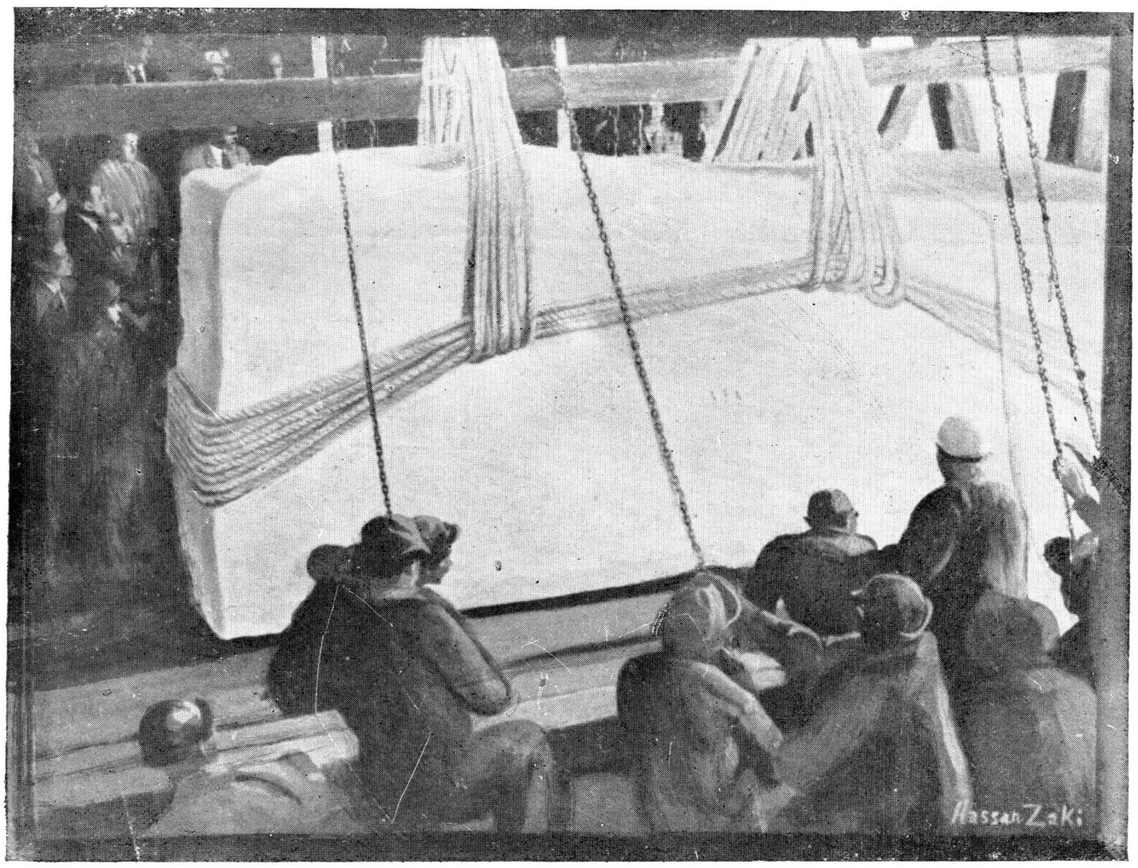


A.—Outside view for the shelter after being finished.

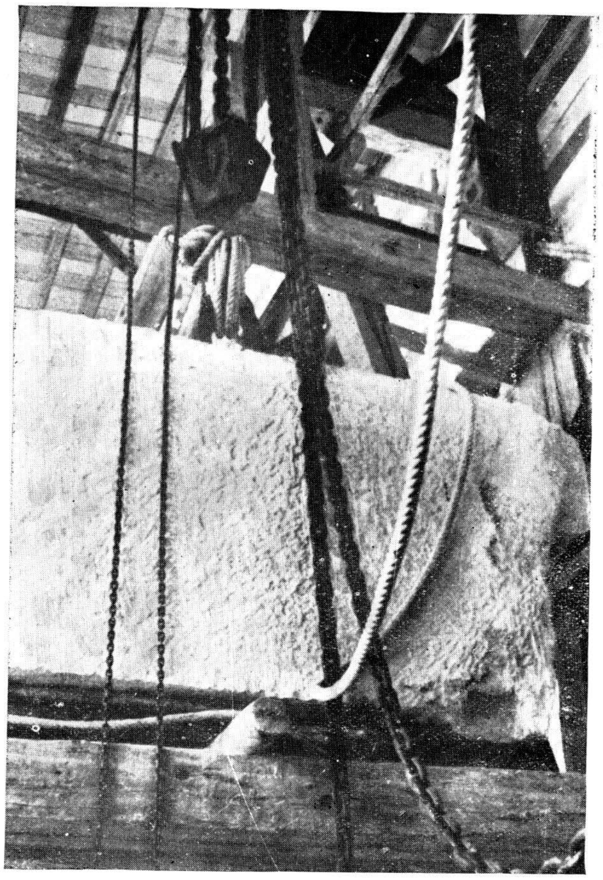


B.—The eastern group of blocks after being cleared ; at the far end to the right appears the keystones group.

A.—The place previously occupied by the keystones.

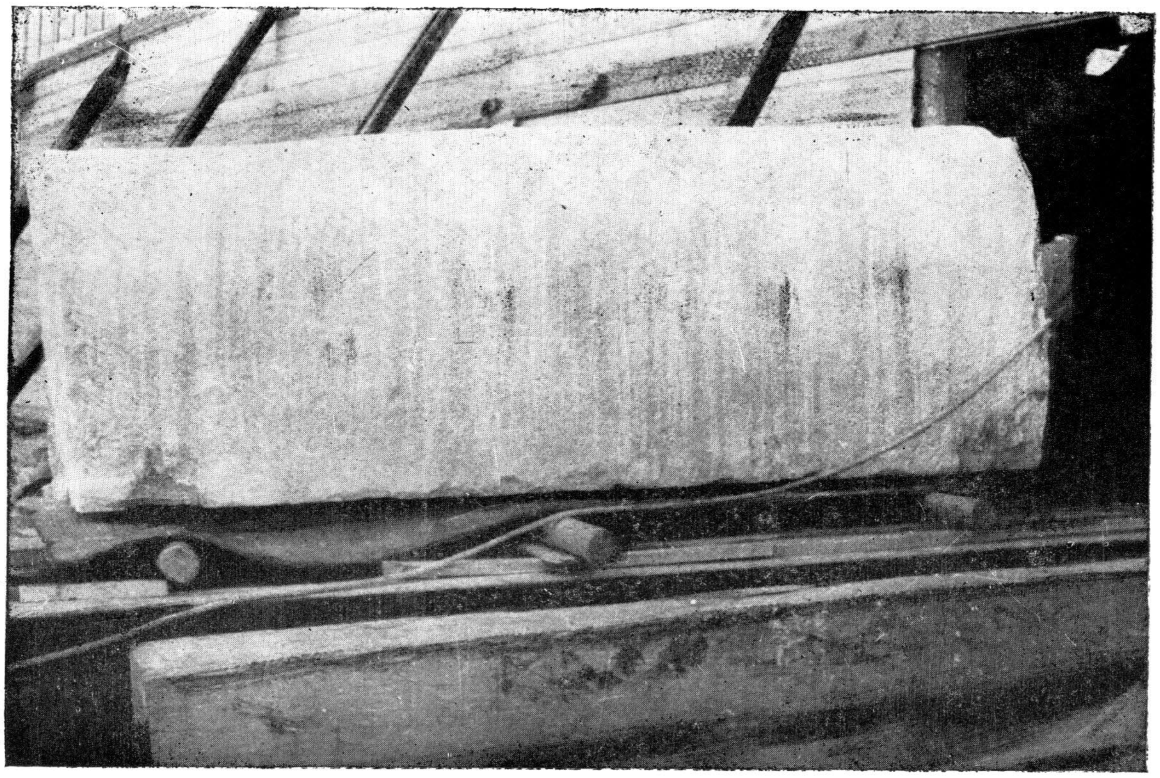


B.—Block No. 1 while being lifted.

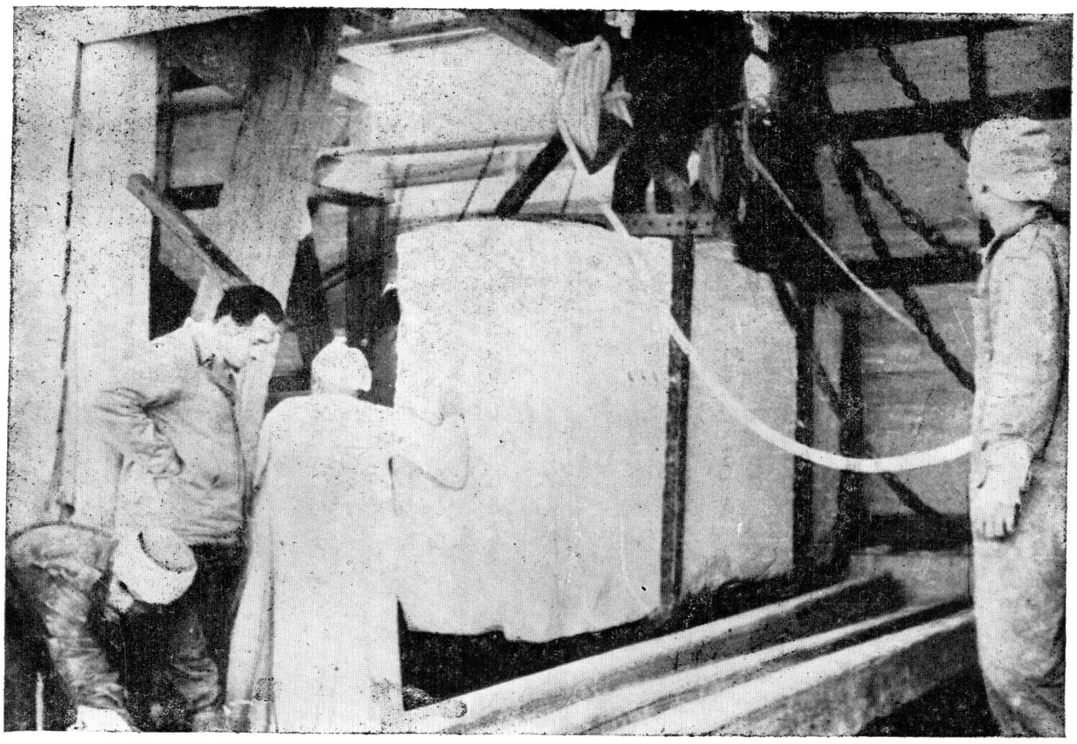


A.—Resting block No. 1 on rollers after being lifted.

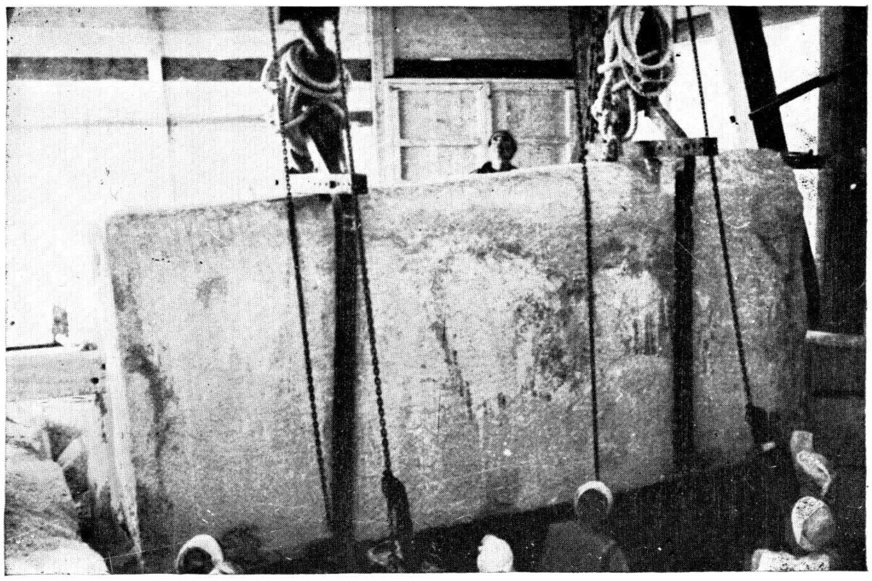
B.—Pulling block No. 1 outside the shelter.



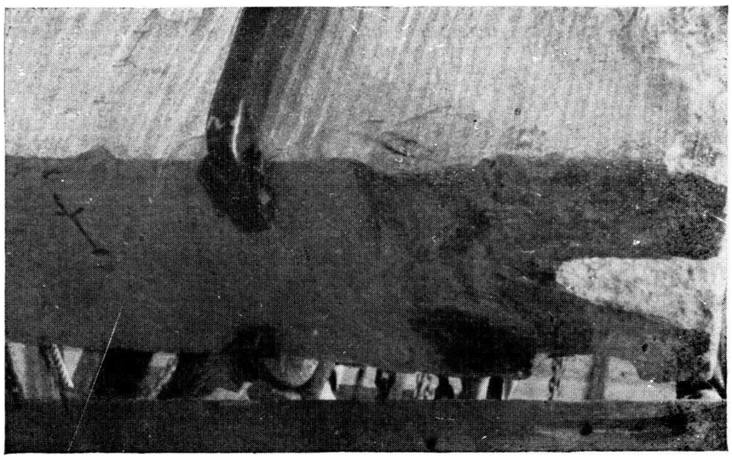
A.—Block No. 1 after being pulled outside.



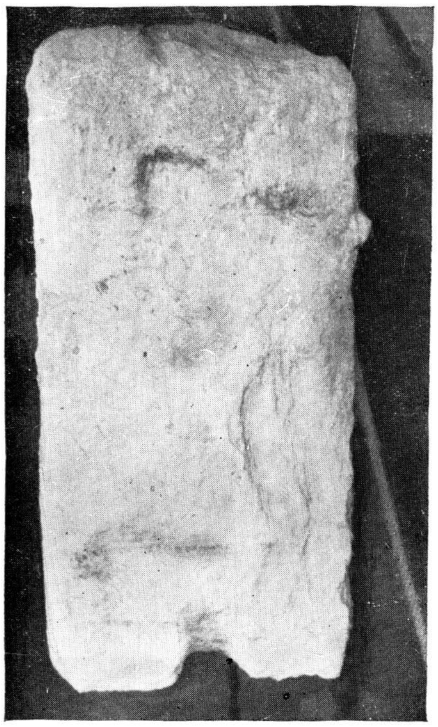
B.—Block No. 2 when it reached the top level of the other blocks.



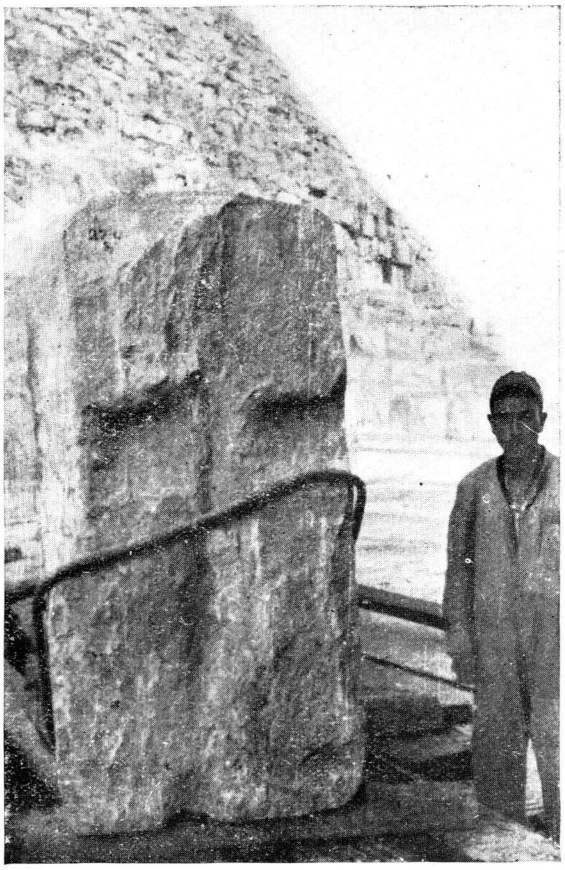
A.—The natural defects treated in block No. 8.



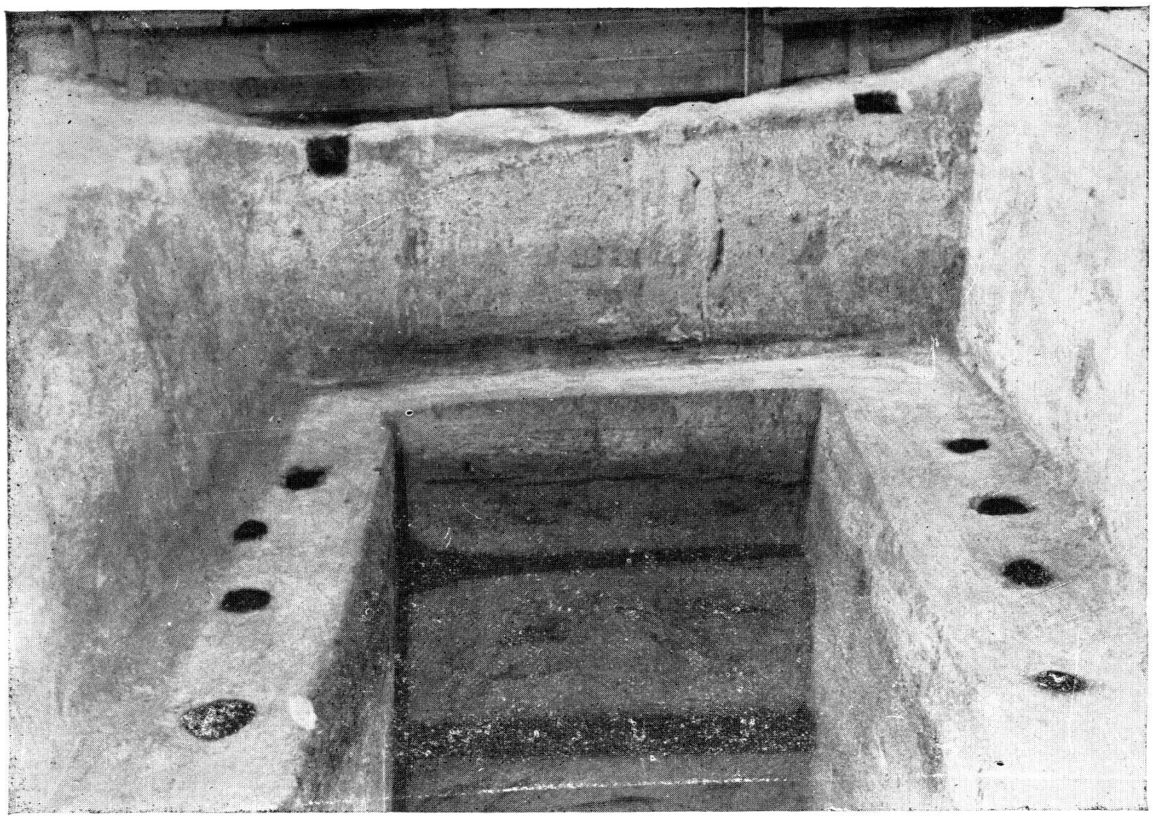
***B*.—The semi-ellipsoidal opening in the extremity of the bottom surface of a block.**



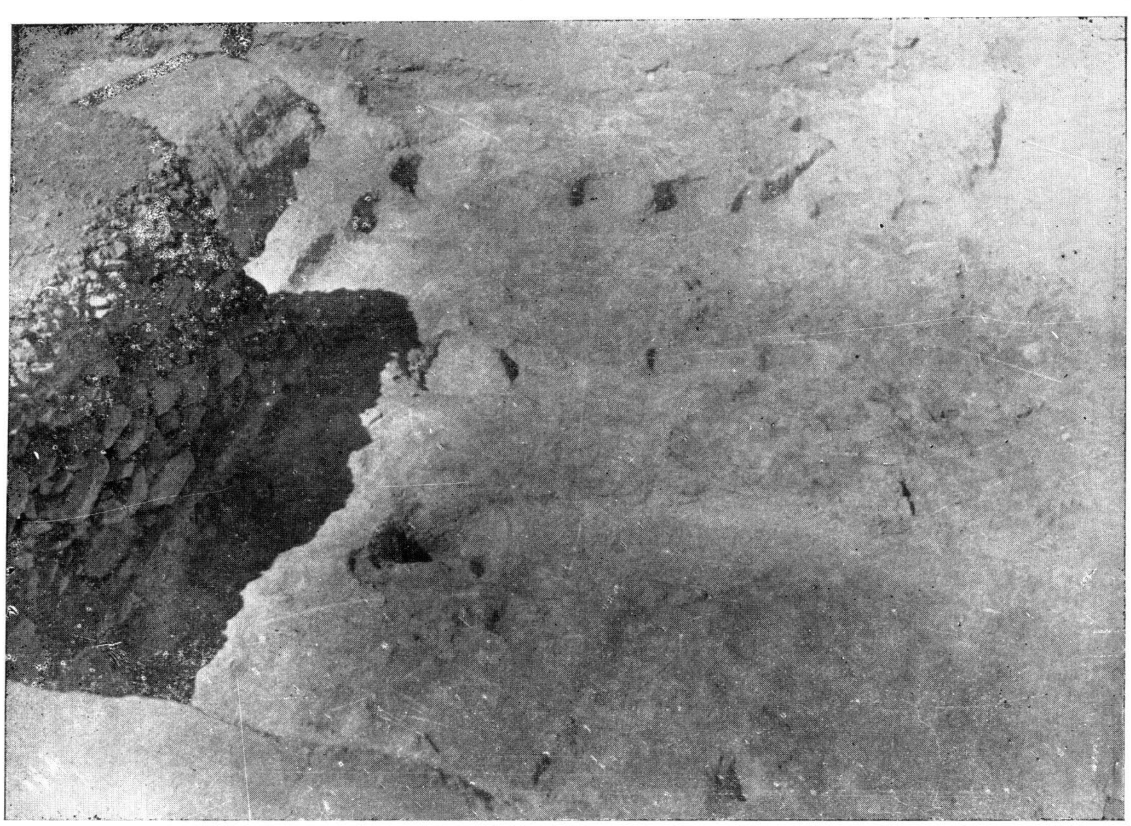
A.—The square hole in the northern surface of a block.



B.—An odd case for the square openings, where there are two openings instead of one.



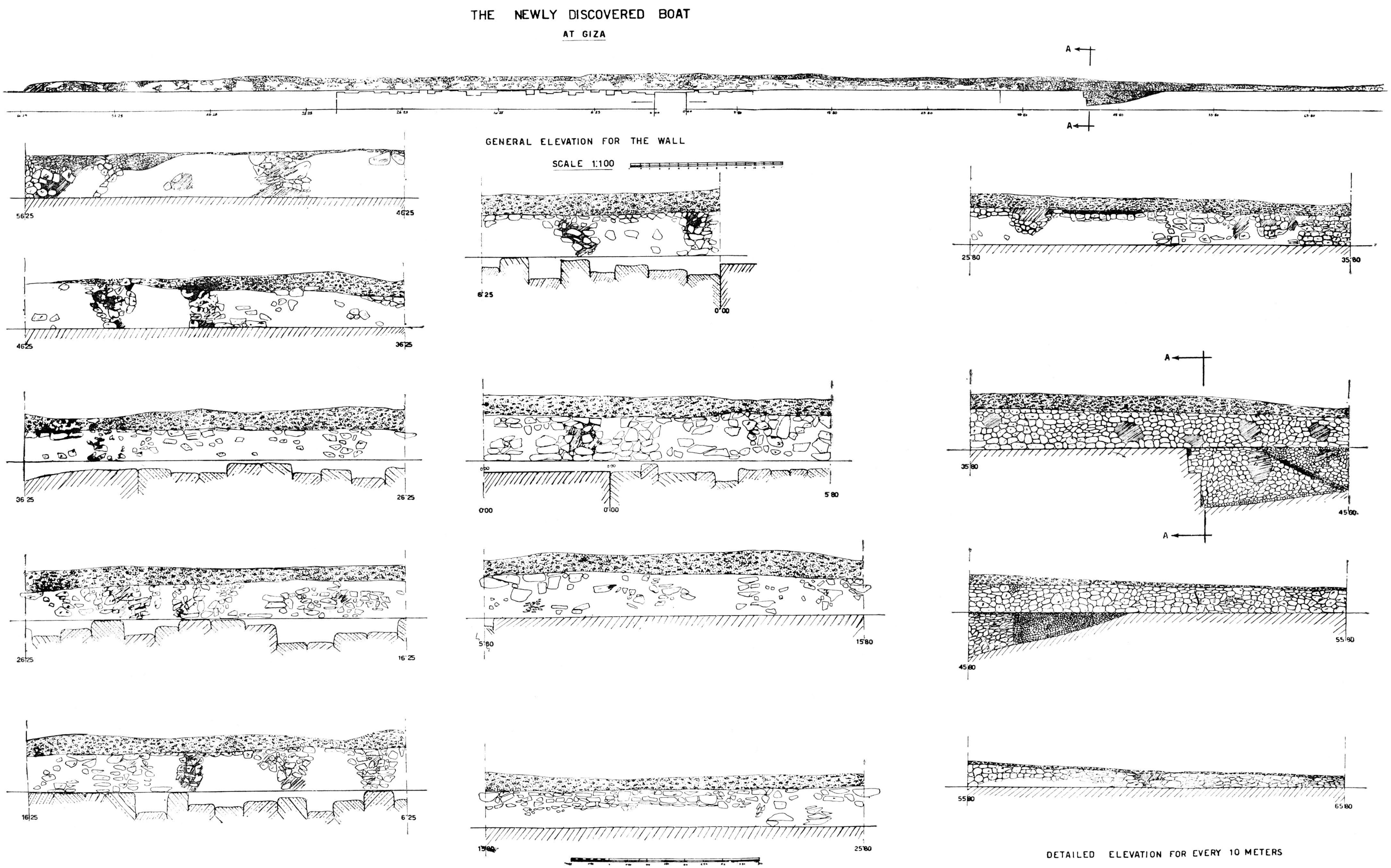
A.—Holes and openings found on the horizontal ledges and the vertical eastern edge of the pit.



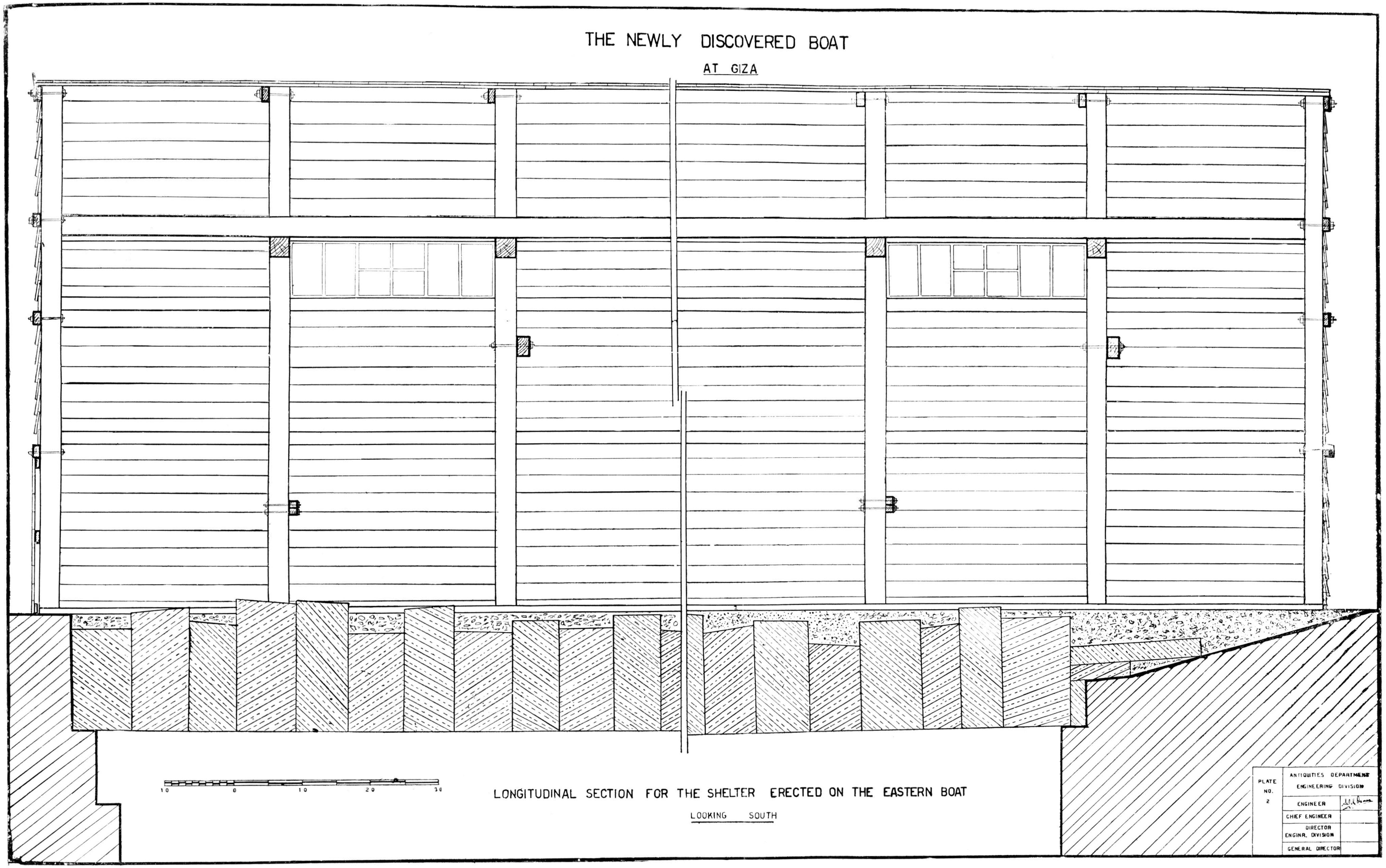
B.—Openings and holes found outside the pit to the east.

*

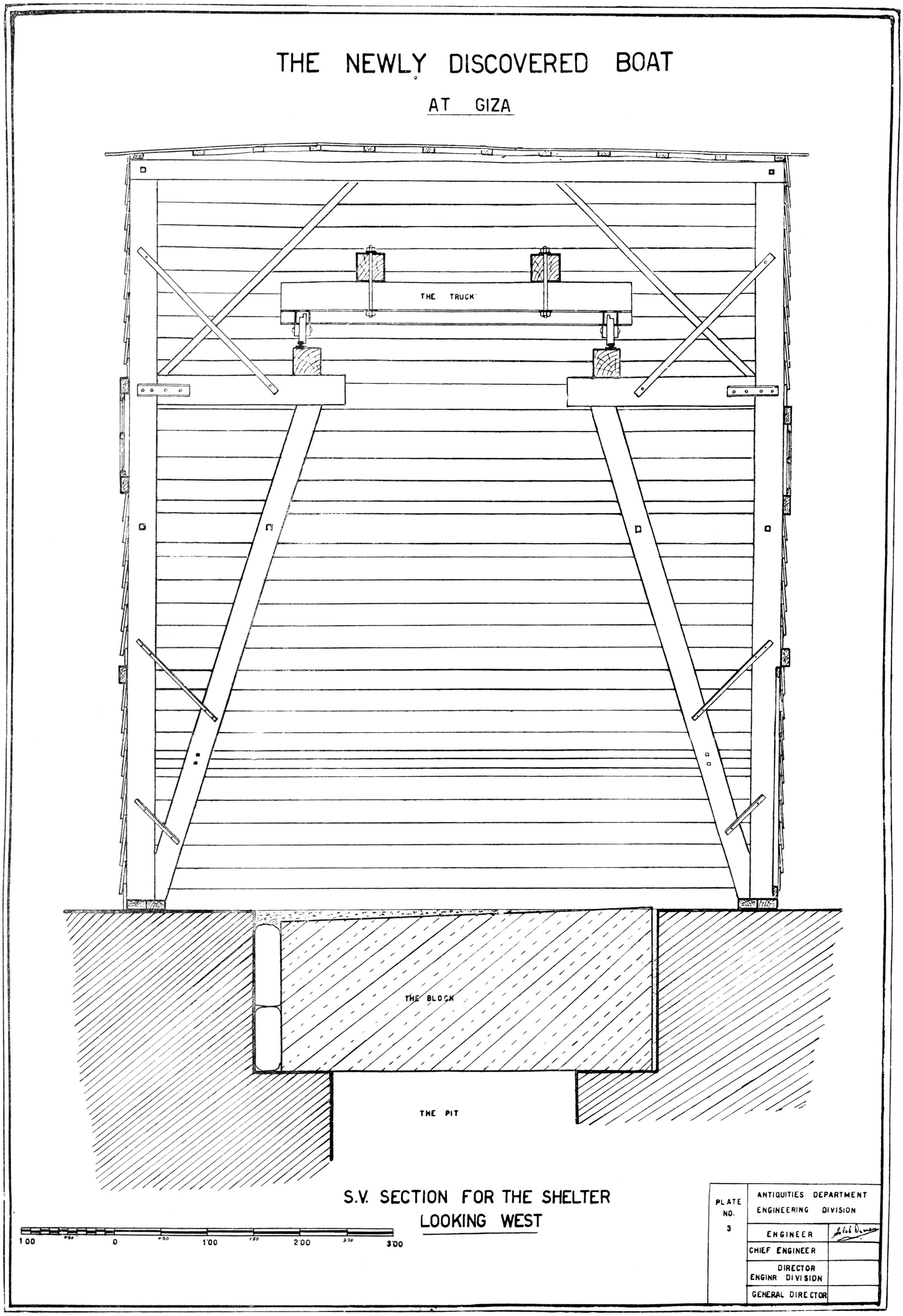
The group of the eastern blocks after being pulled outside the shelter.



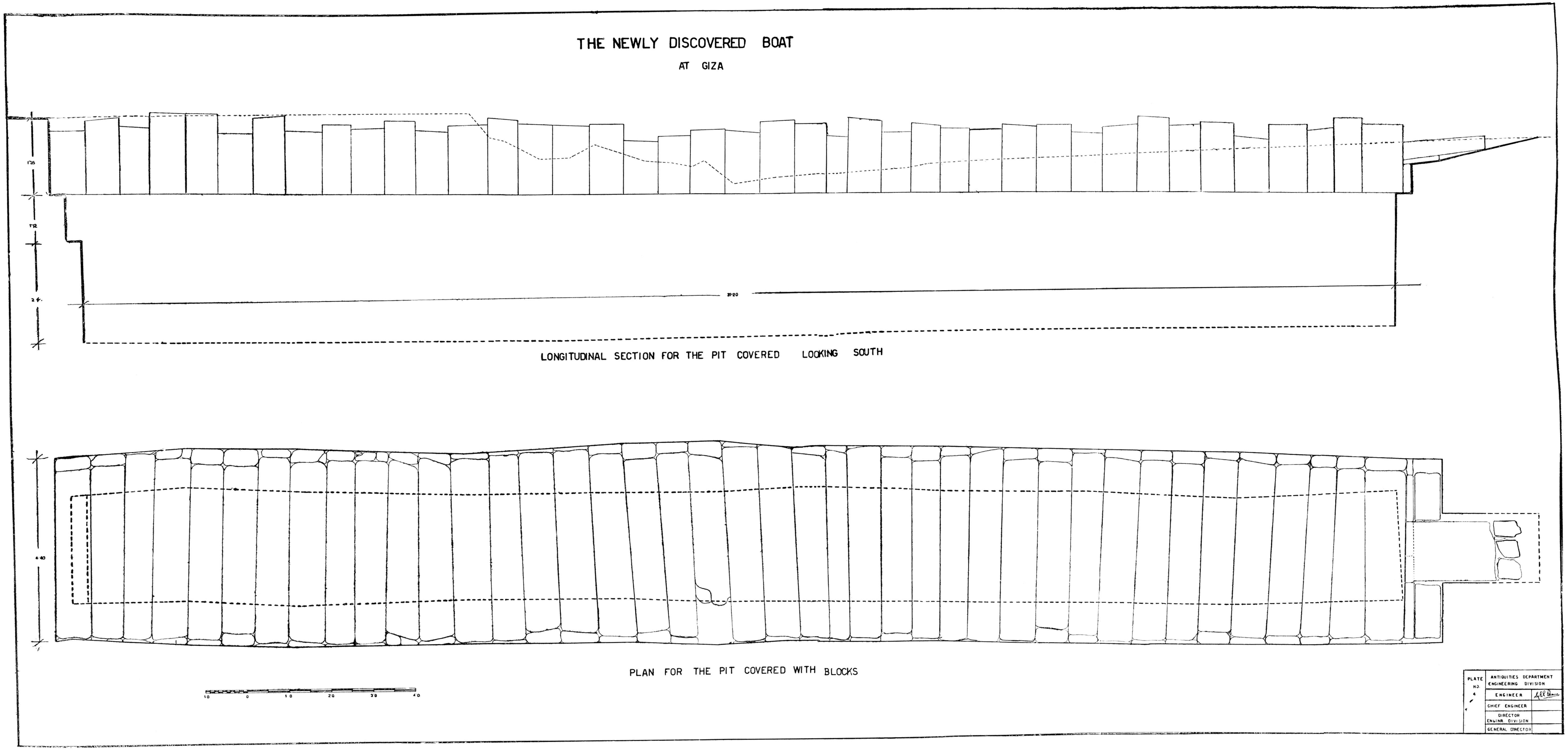
General elevation view for the wall with detailed elevation for every 10 mtrs long.



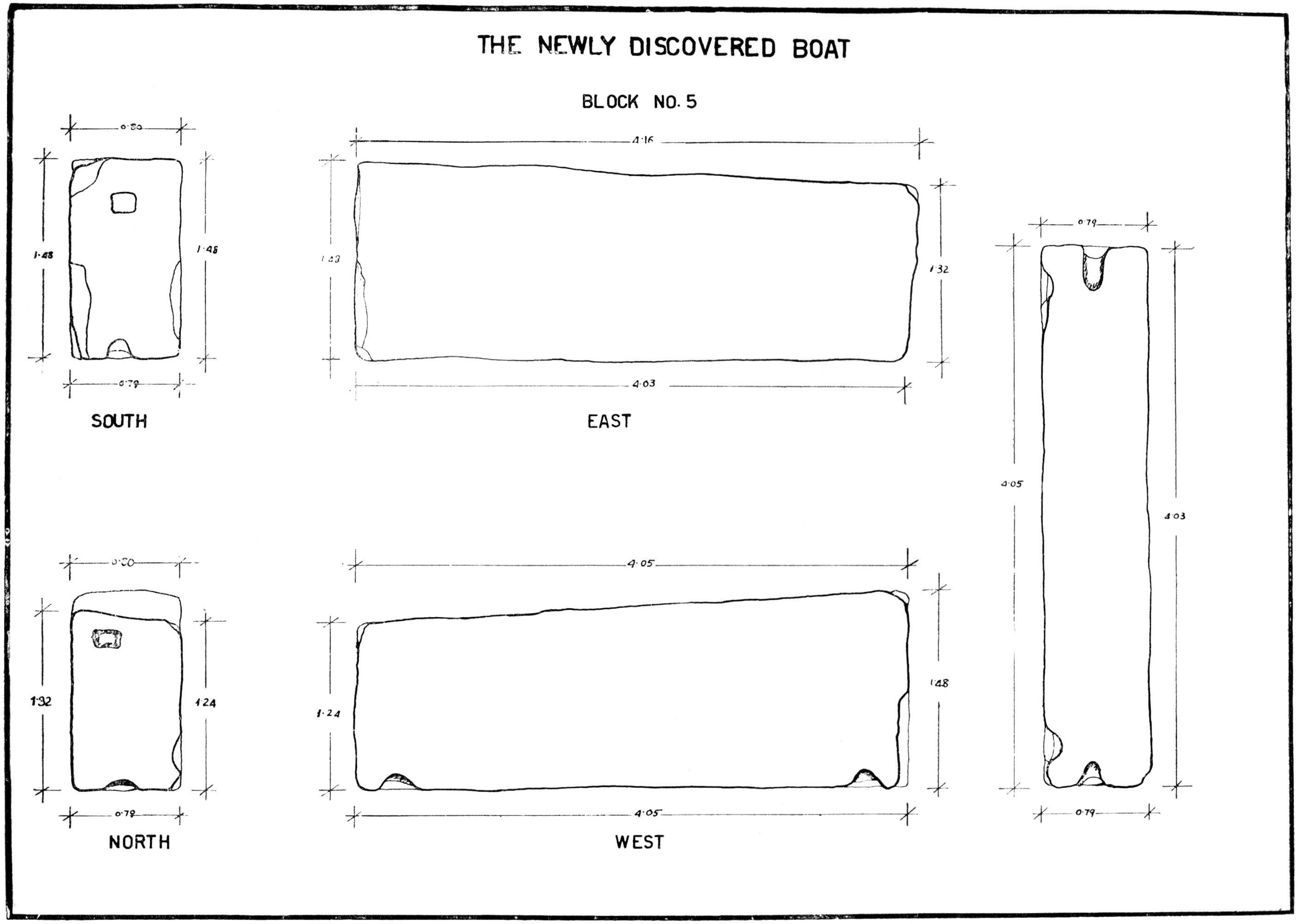
Longitudinal section for the shelter, including the pit covered with the blocks.



Transverse cross section of the shelter, showing the construction of the dolly truck.



Longitudinal section for the pit covered with the blocks looking south and plan for the pit covered. In both the section and plan appear the five keystones.
The small stone shutters at the extrémities of each block appear in the plan.



Elevation for five surfaces of block No. 5, showing all the details of the openings and holes.

PL. XXX

THE SCIENTIFIC STUDY AND CONSERVATION OF THE OBJECTS AND MATERIALS FOUND IN THE DISCOVERY OF THE WOODEN BOAT AT GIZA (Part I)

BY

Dr. ZAKY ISKANDER

The scientific study of the different samples and objects discovered in any excavation is very important since from this study, a full understanding of the materials used and the industries practised during the historical period of the discovery, can be achieved. Moreover, the interpretation of the analytical results obtained may solve, or help to solve, many of the archaeological problems met with, and direct us to the right procedure for the conservation of the objects found. For these reasons, Professor Moustafa Amer, the Director General of the Department of Antiquities at the time of the discovery of the Boat was very keen not to remove any object from its place unless it was scientifically investigated and the results of the investigation submitted to him

After removing the heaps of sand which accumulated on the pavement of the pavement of the Great Pyramid from the southern side, an enclosure wall was found. Under this wall, was found a layer of compressed ground (Fig. 7), to which the arabic word *Dakkah* will be used. This Dakkah covered two separate collections of huge limestone blocks (Fig. 6). Each of these 2 collections, in turn, covered a pit carved in the limestone of the Giza plateau (Fig. 10). The limestone blocks covering the eastern pit were removed and parts of a wooden boat almost completely filling the pit were found. (Pl. XXXI).

The Dakkah, the Blocks and the Boat will be separately considered from the scientific point of view in the following :

THE DAKKAH

As mentioned above, the Dakkah constituted a layer which was spread over the limestone blocks. It is of variable thickness and is not homogeneous in structure. It is mostly made of a greyish white powder, and contains pieces of limestone of different sizes, wood scraps, and chorcoal fragments.

The Powder

Qualitative analysis of samples of the powder showed that it is mostly composed of calcium carbonate, and contains much sodium chloride, some silica, ferric and aluminium oxides, magnesium carbonate, and variable proportions of calcium sulphate. Since the local limestone at Giza contains all these constituents, it is concluded that this powder is mostly composed of powdered limestone.

The Wood Scraps

These are of different sizes and of irregular shapes, denoting that they are remains of carpentry work.

A large scrap (approximately $22 \times 7 \times 2.5$ cms.) which was found 2.6 metres to the east of the limestone block No. 41 was examined microscopically in the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks, England, by Dr. E.W.J. Phillips who reported that "it agrees with *Cedrus* (presumably cedar of Lebanon, C. Libani)". Dr. Phillips examined also another fragment of wood which was found above the block No. 41 and reported that "it is a species of *Acacia*. Of the species represented in our collection, it agrees most closely with *Acacia arabica*".

Since Cedar and Acacia woods are among the kinds used for making the boat as will be mentioned later, it is concluded that the wooden fragments found in the Dakkah might be of the scraps left after making the different parts of the boat.

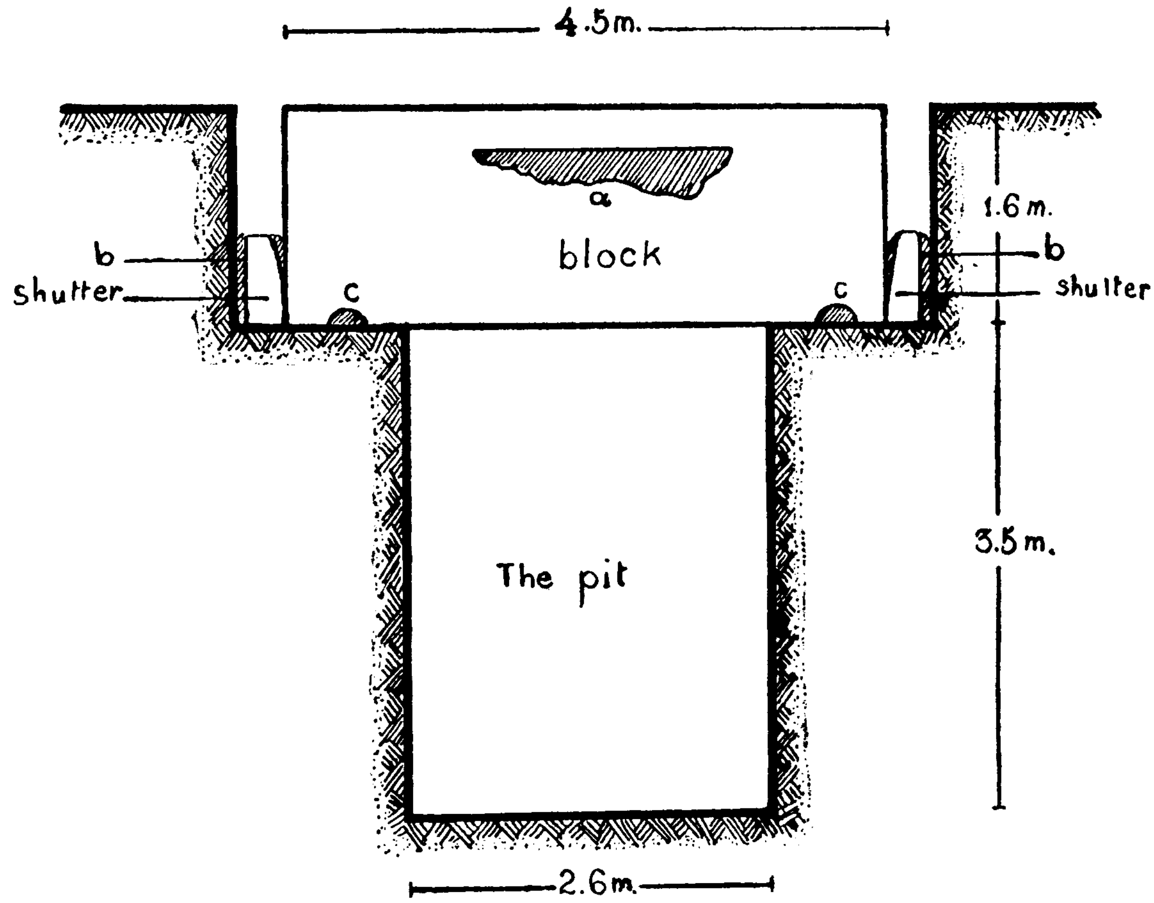


FIG. 10.—Transverse section showing the positions of gypsum mortar in a, b and c.

From the above, it is concluded that the Dakkah is most probably of the debris left after the different processes of preparing the pit, the boat, and the blocks. Thus the limestone powder and the limestone pieces were possibly left after carving the pit and the blocks; some of the gypsum might have remained from the mortar used in connection with the blocks as will be explained later; the wood fragments might be of the scraps left after making the different parts of the boat; and the charcoal fragments might be the remains of the fuel used for preparing the glue solution which might have been used for sticking the various parts of the boat together.

THE BLOCKS

These huge blocks (about 4.5×0.85×1.6 m.) are of limestone, the origin of which is not yet definite. The points of interest observed with regrads these blocks are the following :

1.—Mortar used in Connection with the Blocks

Mortar was noticed in the different parts of the blocks and was used for the following purposes :

(*a*) For filling the defects in the eastern and western surfaces of the blocks (Fig. 10, *a* and Pl. XXII, A), so that the opposite surfaces of every two adjacent blocks might be fairly dressed in order to fit well together leaving the minimum spaces possible between them.

(*b*) For sticking the limestone shutters to the northern and southern sides of the blocks so that they might be stable in their places (Fig. 10, *b*).

(*c*) For filling the semi-circular openings carved in the lower edge of the western side of each block (Fig. 10, *c* and Pl. XXXII, A). These two openings were most probably made to push the block through them, with a lever, to the east side, to be close to the one before it.

(*d*) For sticking the blocks together from their upper and lower sides so that the pit might be air-tight (Fig. 11, *d*). Some pieces of this mortar fell down on the surface of the boat (Pl. XXXI).

(*e*) For filling any spaces found between the adjacent blocks by pouring into them, from above, a thin paste of mortar. The mortar trickled down the sides of the blocks (Fig 11, *e*) and many remains of it are still found on these sides (Pls. XXI, A and XXXII, A).

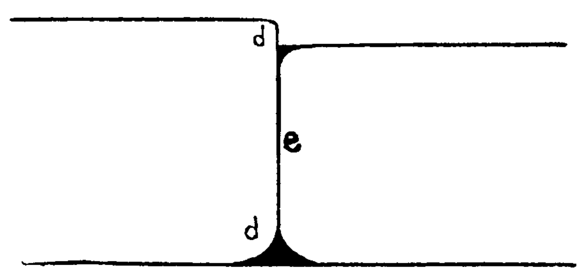


FIG. 11.—Longitudinal section showing the position of gypsum mortar used for sticking the blocks together in *d* and *e*.

The mortar used in *a*, *b*, and *c* is coarse and pinkish white. Chemical analysis showed that it is mostly composed of calcium sulphate and contains some silica, iron and aluminium oxides, calcium carbonate, sodium chloride and magnesium carbonate. The mortar used in *d* and *e* is fine and almost white and proved to be almost wholly composed of calcium sulphate and contains much lower proportions of the above constituents.

Two samples of the mortar used in each of these five positions were quantitatively analysed in the Chemical Department, Cairo, and the following results were obtained, or calculated, for the dried samples (*see* Table I) :

TABLE I

	a		b		c		d		e	
	1	2	3	4	5	6	7	8	9	10
Combined water	17.34	16.94	3.90	16.79	16.40	16.70	16.60	19.36	20.72	18.06
Loss on ignition	2.72	4.46	26.56	2.68	3.80	3.80	6.13	1.88	0.02	3.68
Insoluble in hydrochloric acid	7.86	6.93	16.74	9.01	9.20	7.80	7.38	1.65	0.68	0.76
Iron and aluminium oxides	2.11	2.73	1.60	0.95	1.00	1.40	0.50	0.60	0.43	0.15
Phosphorous pentoxide ...	0.13	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.03	tr.
Calcium oxide	30.44	32.10	40.20	30.47	30.50	30.40	34.40	32.50	32.26	33.59
Magnesium oxide	0.76	tr.	0.14	0.13	tr.	tr.	tr.	0.83	tr.	0.14
Sulphur trioxide	38.54	36.32	9.31	39.38	38.93	39.10	35.60	43.01	46.04	43.05
Chlorides (calculated as sodium chloride)	0.59	0.44	1.46	0.58	0.50	0.60	0.50	0.47	0.23	0.29
TOTAL	**100.49**	**99.92**	**99.91**	**99.99**	**100.33**	**99.80**	**101.11**	**100.30**	**100.41**	**99.72**

Sample No. 1.—Mortar used for filling the defects in the eastern surface of block No. 16.

" " 2.—Mortar used for filling the defects in the western surface of block No. 20.

" " 3.—Mortar used to stick a shutter to the northern end of block No. 6.

" " 4.—Mortar used to stick a shutter to the southern end of block No. 8.

" " 5.—Mortar used to fill the southern semi-circular opening in the western edge of block No. 4.

" " 6.—Mortar used to fill the northern simi-circular opening in the western edge of block No. 17.

" " 7.—Mortar used to stick block No. 6 to block No. 7 along their lower edges.

" " 8.—Mortar used to stick block No. 12 to block No. 13 along their upper edges.

" " 9.—Thin mortar found in between the western side of block No. 4 and the eastern side of block No. 5.

" " 10.—Thin mortar found in between the western side of block No. 12 and the eastern side of block No. 13.

From these results, the composition of the samples was calculated. From the percentages of combined water and sulphur trioxide, the percentages of hydrated calcium sulphate (gypsum, $CaSO_4 . 2H_2O$) and anhydrous calcium sulphate ($CaSO_4$) were calculated. From the percentage of the excess calcium oxide than what is needed for the calcium sulphates, the percentage of calcium carbonate was calculated. The difference between the percentage loss on ignition and the percentage of carbon dioxide needed for calcium and magnesium carbonates, was considered as fuel remains. The calculated composition of these samples is summarised in Table II.

TABLE II

Composition	a		b		c		d		e	
	1	2	3	4	5	6	7	8	9	10
Silica	7.86	6.93	16.74	9.01	9.20	7.80	7.38	1.65	0.68	0.76
Iron and aluminium oxides.	2.11	2.73	1.60	0.95	1.00	1.40	0.50	0.60	0.43	0.15
Hydrated calcium sulphate	82.84	78.09	18.63	80.22	78.36	79.79	76.54	92.48	98.98	86.29
Anhydrous calcium sulphate	—	—	1.09	3.52	4.23	3.40	—	—	—	4.96
Calcium carbonate	5.91	11.93	60.14	5.18	5.80	5.41	16.34	4.26	—	6.16
Calcium phosphate	0.28	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.07	tr.
Magnesium carbonate ...	1.61	tr.	0.29	0.27	tr.	tr.	tr.	1.75	tr.	0.29
Sodium chloride	0.59	0.44	1.46	0.58	0.50	0.60	0.50	0.47	0.23	0.29
Fuel remains	—	—	—	0.26	1.25	1.42	—	—	—	0.82
TOTAL	**101.20**	**100.12**	**99.95**	**99.99**	**100.34**	**99.82**	**101.26**	**101.21**	**100.39**	**99.72**

The composition of these samples shows that the mortars used in *a*, *b*, and *c* were made of gypsum which contains comparatively high percentages of quartz sand, calcium carbonate and ferric & aluminium oxides as natural impurities. This quality of gypsum was probably obtained from the gypsum which occurs in the Giza district just below the surface of the limestone desert.(1) The mortars used in *d* and *e* are compartively much purer specially those represented by Nos. 8, 9 & 10. Sample No. 9, for example, is about 99% pure. Such a quality of mortar must have been made of gypsum of better quality which occurred, and still occurs, in the Fayum and which was reported by Miss Caton-Thompson that it had been worked since the Early Dynastic Period.(2) This better quality of gypsum mortar was chosen by the Ancient Egyptians for use in *d* and *e* on account of :

(*i*) its white colour so that it might match the colour of the limestone blocks in order that the whole ceiling of the pit might appear as one piece, and

(*ii*) its low content of sand so that it might be fine enough to trickle in, and fill, the very narrow gaps between the adjacent blocks.

(1) A. LUCAS, *Ancient Egyptian Materials and Industries*, 3rd Edition, 1948, p. 97.

(2) G. CATON — THOMPSON & E. W. GARDNER, *The Desert Fayum*, p. 103.

Some samples of these kinds of mortar suitable for exhibition were kept to be exhibited in the local museum which will be constructed specially for the discovery of the two boats.

2.—Tools used for Dressing the Surfaces of the Blocks and the Pit

FIG. 12.—Microphoto of a fragment of corroded copper found sticking to a side of a block, 41x, polarised light.

The surfaces of the pit and blocks were certainly dressed mainly with chisels since chisel marks are apparent on their sides (Pl. XLIV). Since the chisel marks are either flat or concave, it is concluded that straight-edged chisels as well as gouges-which leave concave marks - were most probably employed. Pointed tools were also used as shown by the presence of some deep narrow markings on some areas of the sides of the blocks and the pit.

Very small fragments of corroded copper were found sticking to the different sides of the blocks. These fragments are apparently broken edges of the tools which were used for dressing the surfaces of these blocks. They were chemically and physically examined by the following means to find out their original shape and composition :

(1) *Metallographic Examination.*—This was done with the kind permission of Dr. Paul Coremans in the Laboratoire Central des Musées de Belgique, Bruxelles, during my scientific visit to this laboratory in August 1956. Mademoiselle Goorieckx and myself cooperated in choosing a suitable fragment for which a slide was prepared and examined in the metallographic microscope. Mademoiselle Goorieckx prepared for this fragment two microphotos (Figs. 12 and 13) in polarised light which show the original shape of this fragment.

She reported the following explanation for the two microphotos :

Fig. 12. Microphotos L. 2850—2851 E. (moitié gauche et moitié droite de la coupe transversale du fragment, assemblées par le centre) Minéralisation très poussée du fragment de cuivre, les restes métalliques prouvent la nature et la forme originelle du fragment gross. 41x, lumière polarisée.

FIG. 13.—Microphoto of the previous fragment
22.5 x, polarised light.

Fig. 13. Microphoto L. 2852 E. un fragment, gross. 22·5x lumière polarisée.

The form of the fragment shown in the two microphotos indicates that it is a broken edge of one of the copper chisels used for dressing the surface of the block.

(2) *X-Ray Spectrochemical Analysis.*—This was done in The Philip's Company Laboratories in Eindhoven, Holland, during my scientific visit to these laboratories in July 1956. Dr. G. L. Devries and myself collaborated to analyse some minute fragments of the corroded copper under consideration by X-Ray spectrography. The curve obtained (Fig. 14) showed that these fragments contained essentially copper, very little iron, and small traces of lead. No tin could be detected even on doing the analysis under vaccuum, thus proving that they were of copper and not of bronze.

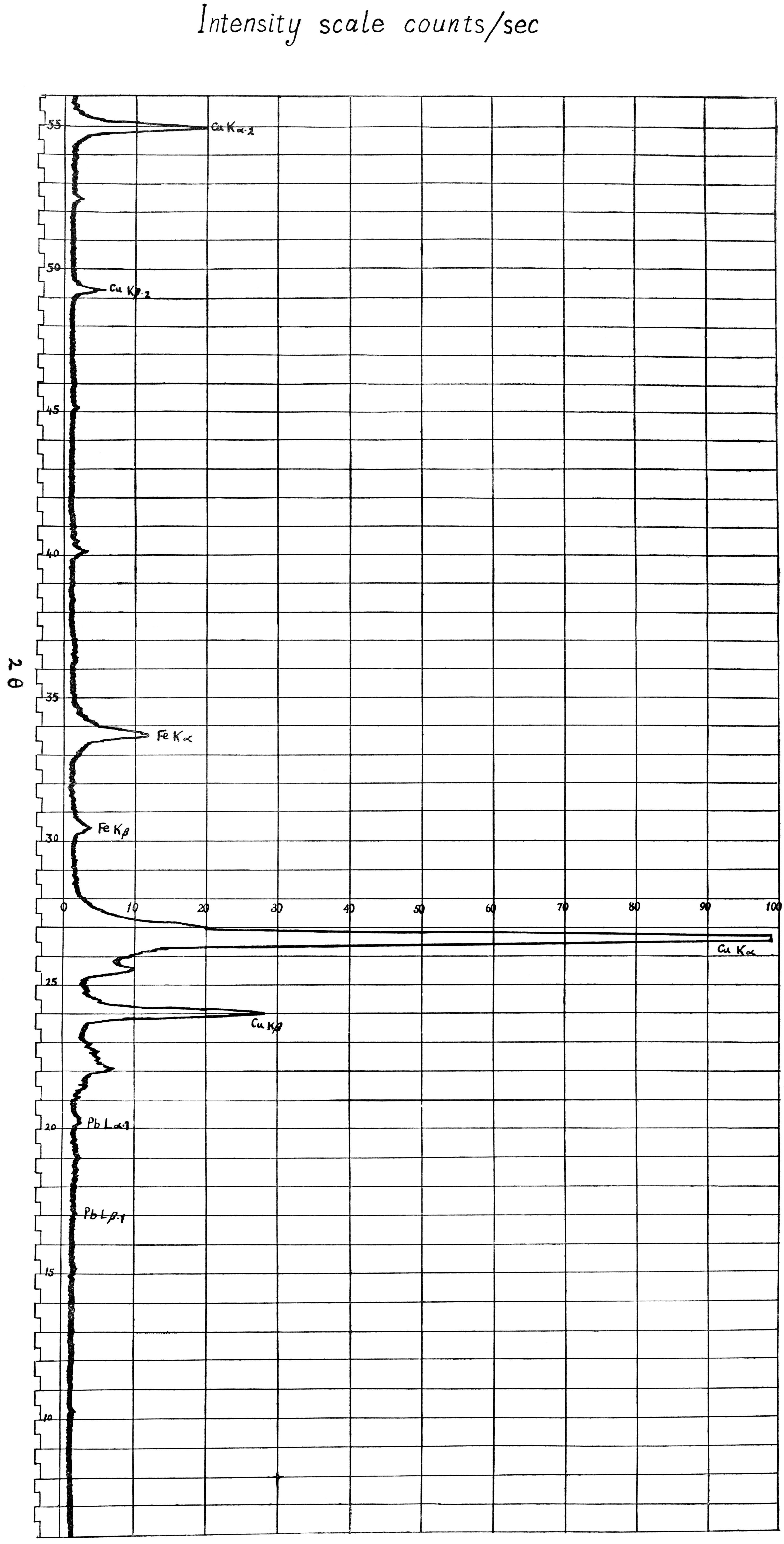


FIG. 14.—X-Ray fluorescence spectrum of small fragments ot corroded copper found sticking to the sides of the limestone blocks, 50 kv, 18 m A, × 16×1, 1° 1 cm/minute, time constant 2 seconds.

(3) *Microchemical Analysis.*—This was done with the kind permission of Dr. H. J. Plenderleith in the Research Laboratory, British Museum, London, during my scientific visit to this laboratory in September 1956. Miss Bimson and myself collaborated in analysing a small fragment of the corroded copper weighing 0.0028 gram. Spectrophotometric analysis of this fragment showed that it contained 1.4% of iron and 21.5% of copper. These two metals can be considered as the main or the only constituents of the sample since its X-ray absorption spectra recorded in fiig. 5 showed that lead was only found in very small traces which can be neglected. The composition of the original metal, before corrosion, can be considered, therefore, as $\frac{21.5 \times 100}{21.5 + 1.4} = 93.9\%$ of copper, and $\frac{1.4 \times 100}{21.5 + 1.4} = 6.1\%$ of iron.

All these results show definitely that the tools used anciently for cutting the blocks and dressing their surfaces were of copper.

This fact supports strongly the views that Herodotus was not right in saying that iron tools were used in connection with the working of the stones of the Great Pyramid [1, 2].

3.—Red Pigments

It was observed that most of the eastern surfaces of the blocks contained remains of some red painting. Chemical analysis showed that it is composed mainly of a mixture of red ferric oxide (red ochre) and calcium carbonate (finely ground limestone).

4.—Quarry Marks

Quarry marks in red brown, black, and yellow colours were found on many of the sides of the blocks. These proved to be of red ochre, carbon (probably soot), and yellow ochre respectively.

Most of these quarry marks or inscriptions, except those depicted on the bottoms of the blocks, were covered with layers of crystalline common salt or of gypsum mortar strongly adhering to them. These layers were mostly removed mechanically at first, and then with a fine spray of water. After drying, they were all sprayed with some preservative coats of 7% poly-vinyl acetate solution.

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(1) Herodotus, *Histories*, II, 125.

(2) A. Lucas, *Ancient Egyptian Materials and Industries*, London, 1948, pp. 269-271.

THE BOAT

Inside the rectangular pit (about 31.2 m. long, 2.60 m. wide and 3.5 m. deep) were lain the parts of the Boat. The boat was not completely constructed but it contained many loose pieces which were merely piled up on its surface or introduced between the main body of the boat and the walls of the pit. The most important scientific points connected with the boat are the following :

1.—Relative Humidity Inside the Pit and its Relation to the State of the Wood of the Boat

The ancient overseers of the work took all possible precautions to make the pit almost completely air-tight. Thus, as mentioned above, the blocks were stuck together with plaster of Paris from the bottom side, thin mortar of plaster of Paris poured in between every two adjacent blocks, the upper sides stuck together with plaster of Paris and finally the whole surface of the blocks was covered with the Dakkah. After closing the pit, the wood and the other plant fibres used for making the mats, ropes and cloth started to dry up, but the moisture could not escape out of the air-tight pit. This drying up of the contents of the pit continued only for a short time until the atmosphere in it became saturated with moisture. An equilibrium took place between the moisture in the atmosphere of the pit and the humidity content of the wood. As a result of this equilibrium, the wood of the boat did not suffer almost any more drying, and accordingly, most of it remained in a comparatively good state. This speculation was confirmed by :

(1) *Determining the Humidity Content of the Wood of the Boat.*—Three pieces of wood of different condition and taken from three different places of the boat were sent to the Chemical Department, Cairo, which reported that their humidity contents were 9.0%, 10.0%, and 11.0% respectively, with an average of 10%. This shows that the wood of the boat did not lose a great porportion of its original humidity content, since seasoned wood in Egypt contains about 11—12% of free water.

(2) *Measuring the Relative Humidity in the Pit.*—After lifting up the first block on 23rd November, 1954, a hygrothermograph was put in the closed pit for six days. The curve obtained showed that the relative humidity was 88% at 22° C., which shows that the wood still keeps a good amount of free water, and that it remained in a moist atmosphere during its long existence in the closed air-tight pit.

Fortunately, the author predicted this state directly after making a hole in the block No. 22 on May 26th., 1954 and advised not to open this hole frequently in order to avoid the drying up of the wood and consequently its deformation or disintegration. Moreover, after starting on Nov. 23rd. 1954, to take off the blocks, these were replaced with wooden boards covered with fire- and water-proof cloth in order to minimise as far as possible the rate of the drying up of the wood. (Pl. XXXI, Fig. 8). This procedure was successful to a great extent as shown by measuring the relative humidity inside the pit, at intervals, by means of a hygrothermograph which was left in the pit for some days. The results obtained are recorded in table III.

In all these determinations, the hygrothermograph recorded that equilibrium was regained after about 10 hours from the time of closing the pit (Pls. XXXIII and XXXIV). The relative humidity falls on opening the pit, and rises again on closing it (Pl. XXXIV).

TABLE III

Date	Maximum Relative Humidity		Maximum Temperature	
	In the pit	outside	In the pit	outside
	%	%	°C.	°C.
23–29 November 1954	88*	44	22	18
13–19 December 1954	85†	36	21	18
30 January–6 February 1955	75	51	19	17
26 May–2 June 1955	76	48	23.5	29
7–13 June 1955	78	42	25	33
13–19 June 1955	77	56	25	34
28 June–4 July 1955	80	64	25	38

* *See* Pl. XXXIII † *See* Pl. XXXIV.

During June, as shown in Table III, it was found that inside the pit, the temperature was lower and the relative humidity was higher than the corresponding value outside it. It was decided, therefore, to stop the work during the rest of the Summer so that the wood of the boat might not dry quickly, and be deformed or disintegrated.

2.—Plant Materials used for Making the Matting, Cordage, Basket-work and Cloth Found on the Surface of the Boat

The plant materials used for making the matting, cordage, and basket-work were examined by Professor Dr. Elhamy A. M. Greiss, Botany Department, Faculty of Science, Cairo University, who kindly reported the following :

Anatomical Identification of Plants and Plant Materials Excavated with the Wooden Boat.

Since the wooden boat dates back to Pharaonic times, the study of plants and plant materials, that were with the boat would throw some light on plants that were present at that time.

The plant materials found were mostly devoid of morphological characteristics, so that the identification of the specimens, had to be based on the anatomical characters of the plants collected.

The boat was almost completely covered with different types of mats, ropes . . etc. The samples that were provided for identification, were brown cylindrical fragments, parts of mats, flat ribbons and ropes. The specimens were dark brown in colour and in spite of their great age some of them were still hard, and microscopical preparations were easily prepared from them ; others were badly preserved and in a state of decomposition. They were so brittle that they could be hardly handled.

After many trials, the writer succeeded in preparing cross sections and epidermal strips from the different materials.

Microscopic examination of the provided material showed that they were as follows :

(*a*) The cylindrical fragments, 5–10mm. in diameter and a large mat of thin culms cut lengthwise, were parts of culms, with nodes and internodes of *Phragmites communis* (L.).

(*b*) The brown flat thin mats were made of split culms (about 1mm. thick) of *Juncus arabicus* (Asch. et Buch) Adams.

(*c*) The brown ropes were of light brown colour and varying in length and thickness, some of them were either tightly or loosely twisted. These ropes were made of leaves and culms of *Desmostachya bipinnata* (L.).

(*d*) The dark brown flat ribbons (5–7mm. broad) were either found in rows one above the other or tied together with strings, in the form of a mat. These ribbons were leaves of *Typha australis* (Shum et Thom.).

The strings tying the leaves were found to be composed of tubular units, possibly fibres but, they were so charred and badly preserved that a through investigation was not possible.

It is interesting to mention, that till the present days the same plants are still used in making similar mats and ropes.

Thanks are due to Dr. M. Amer, head of the Egyptian Antiquity Service and to Dr. Zaky Iskander, Chief Chemist of the Egyptian Museum of Antiquities, Cairo, for providing the material for identification.

Dr. E. A. M. Greiss

The fibres used for making the cloth were so charred that they could not be identified microscopically, but the chemical behaviour of this cloth on ignition and towards acids and alkalies shows that it is made of plant fibres. The general appearance of the cloth indicates that it may be of linen.

Linen fabrics have been found in Egypt even from Neolithic[1] Badarian[2] and Predynastic[3] Periods and therefore, from the archaeological point of view, the identification of the cloth as linen is not against the known facts.

3.—Distribution of Objects on the Surface of the Boat

The surface of the boat contained five distinct zones. The names of plants mentioned in the description of these zones are according to the anatomical identification of Dr. Greiss as previously stated in his report above. Starting from the west side of the boat the following zones were observed :

(a) *The First Zone.*

This is about five metres long and contained independent layers of mats ranging from 3 to 6, piled up over each others. Most of the surface parts of the boat in this zone were covered with these layers of mats, as well as many parts of them fell down on the lower parts of the boat or on the floor of the pit. The usual arrangement of the matting in these layers is the following, starting from the surface downwards :

(*i*) Matting of the leaves of Typha australis arranged transversally and sewn together with threads (Pl. XXXV).

(*ii*) Matting of thin slices of juncus stems (rushes) interwoven in the form of narrow net-work (Pl. XXXV).

(*iii*) Matting of Typha leaves arranged longitudinally or transversally and sewn to gether with threads.

This arrangement of layers is repeated in some of the places as in mats Nos. 4, 7 and 8 in which six layers of mats are found. In others, only one or two of these layers are repeated as in the mats Nos. 9 and 11.

Under these layers of mats were found in a few cases, some ropes of Halfa grasses hanging downwards (Pl. XXXII, B) as in the mats Nos. 2 and 7.

Typha was rarely found in the graves of Ancient Egypt, but it was certainly known since long time. Thus Brunton found remains of Typha from the Badarian Period[4]. Typha leaves are used in the present time for making ordinary mats (called in Arabic "akiab"), huts and bottoms of chairs[5].

Juncus (or rush) was used for making mats since the Neolithic Period.[6] Midgley[7] described the method of making mats of rushes from the Badarian Period as follows : " The rushes laid in parallel lines in layers, the direction of one layer being approximately at right angles to the other. Several layers thick, compacted by pressure ".

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(1) G. Caton-Thompson and E. W. Gardner, *The Desert Fayum* p. 46.

(2) G. Brunton and G. Caton-Thompson, *The Badarian Civilization*, pp. 64–67.

(3) W. M. F. Petrie, *Prehistoric Egypt*, p. 47.

(4) G. Brunton, Mostagedda, Grave No. 1100 p. 59 Pl. XXV, (37, 40).

(5) Vivi and Gunnar Täckholm and M. Drar, *Flora of Egypt* Vol. I, Cairo, 1941, p. 87–91.

(6) Vivi Täckholm and M. Drar, *Flora of Egypt*, Vol. II, Cairo, 1950, p. 471.

(7) T. Midgley, *The Textiles and Matting*, in G. Brunton and G. Caton-Thompson, *The Badarian Civilization and Predynastic Remains near Badari*, London, 1928, p. 67, Pl. 61: 5–6.

Brugsch[1] identified the Hieroglyphic word *asir*  or  (which is mentioned in Pap. Harris No. I, 19b) as Juncus. This identification is supported by Loret[2] and Jequier[3]. Both of them suggested that this word might have originated from a Semetic word and that it is comparable with the Arabic name for Juncus "asal اسل". It may be of interest, however, to point out here another possibility that the word "hasir حصير", which is used in the Arabic dialect in Egypt to mean the kind of mats made of Juncus, might have originated from the Hieroglyphic word "asir".

(b) *The Second Zone.*

This is about two metres long, *i.e.* extends from m. 6 to m. 7 and is mostly covered with matting of two independent layers (Pl. XXXVI), the upper one of which is made of interwoven thin slices of rushes and the lower is made of Typha leaves which are arranged transversally and sewn together with threads.

(c) *The Third Zone.*

This is about 13 metres long, *i.e.* it extends from m. 8 to m. 20. It is mostly composed of the wooden boards of which were constructed, most probably, the cabins of the Boat. Most of this zone was covered with one layer of matting of Typha leaves which were arranged transversally and sewn together with threads. This layer of matting was covered with a layer of cloth, most probably of linen (as previously explained), of which many parts still remain. Pl. XXXVII shows a part of this zone and Pl. XXXVIII, A shows the back surface of one of the mats in it after being treated for conservation, lifted up and inverted. Pieces of two-strand ropes were also found under or beside some of the mats in this zone. A collection of 5 two-strand ropes were also found passing out through a hole in one of the wooden blocks (Pl. XXXVIII, B). This shows that some of the ropes found in the boat served for binding or lashing some parts of the boat together.

Ropes of Halfa grasses have been found in Egypt from the Neolithic Period at El-Omari[4] and at Maadi.[5]

Nearly at the end of this zone was found a mat of some kind of basket-work which is about 1.4 m. long and 1.0 m. wide. (Pl. XXXIX, A). It is made of interwoven culms of Phragmites communis (common reed). Reeds were used for matting since the

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(1) H. Brugsch, *Dictionnaire Géographique de l'Ancienne Egypte*, p. 897.

(2) V. Loret, *Recherches sur plusieurs plantes connues des anciens Egyptiens*, XII. Le Jonc, *Recueil de travaux relatifs à la philologie et à l'archéologie Egyptiennes et Assyriennes*, T. 16, Paris, 1894.

(3) M. Gustave Jequier, *Matériaux pour servir à l'établissement d'un Dictionnaire d'Archéologie Egyptienne, Bulletin de l'Institut Français d'Archéologie Orientale du Caire*, T. XIX, 1922, p. 229.

(4) E. A.M. Greiss, *Anatomical Identification of Plant Remains and other Materials*, Bulletin de l'Institut d'Egypte, T. XXXVI, Session 1953-1954, pp. 228-230.

(5) O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Maadi*, 1936, p. 49.

Tasian Period.[1] Some of the Badarian[2] and Predynastic[3],[4] matting were made of reeds. Certain First Dynasty mats were also made of reeds (Phragmites communis).[5]

A piece of pottery was found on the mat No. 22 which falls in the square B, 12 (*see* Fig. 22). The cloth and matting under this piece were clean and untorn. This shows that it fell on the surface of the boat anciently before covering the pit with the blocks and when the cloth and matting were still fresh and in good state. This piece is irregular and its maximum dimensions are 9.5 × 5.0 × 1.5 cms. The facts that it is slightly curved, unpolished and badly baked, indicate that it was a fragment of a large jar of those used by the workers for keeping and cooling drinking water.

(d) *The Fourth Zone.*

This is about four metres long, *i.e.*, it extends from m. 21 to 24, and is mostly occupied by four wooden doors piled over each other on larger wooden boards. This zone was mostly covered with some objects in the form of cushions made of numerous layers of cloth impregnated with a resinous substance (Pl. XXXIX, B).

These objects are possibly fenders (or buffers) which served, most probably, for mitigating collisions of the boat with the shores of the water-streams in which it navigated or was supposed to navigate.

Some of the fenders were originally put on the flat boards of the boat, and it seems that the resinous material with which they were impregnated had become soft enough at the temperature of the pit in some times of the year, that it trickled on the surface as shown in Pl. XL, A. Some other fenders were put on side wooden planks, and therefore, most of the resinous substance trickled on the parts of the boat found underneath them or on the floor of the pit.

In this zone were found also some remains of matting and of cordage.

(e) *The Fifth Zone.*

This is about 7 metres long, *i.e.*, it extends from m. 25 to m. 31, and contains some of the ropes which are still showing that they served for lashing some parts of the boat together.

4.—Kinds of Wood used in Making the Boat

Several kinds of wood were used for making the different parts of the boat and its equipment. Few samples of the wooden parts of the boat were examined microscopically in the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks, England, by Dr. E. W. J. Phillips who reported the following :—

Sample A.—A broken piece from the blade of the oar No. 22 : "probably *Ostrya* species, presumably *Ostrya carpinifolia*, the hop hornbeam of S. E. Europe and Asia Minor."

(1) G. Brunton, *Mostagedda*, pp. 6-7, 33.

(2) G. Brunton and Caton-Thompson, *The Badarian Civilization*, p. 67.

(3) G. Brunton, *Mostagedda*, pp. 36, 62, 93.

(4) R. MacIver, and A. C. Mace, *El Amrah and Abydos*, p. 31 ; Pl. XI (5, 6).

(5) R. Macramallah, *Un cimetière archaïque de la classe moyenne du peuple á Saqqarah*, 1940, pp. 3, 40-42, 47-50.

Sample B.—Piece from the board No. 47: " This seems to be a species of juniper (Juniperus sp.)."

Sample C.—Piece from the beam No. 14: "Probably *Balanites aegyptiaca*, the lalob, soapberry or thorn tree."

Sample D.—Piece of the shaft of the oar No. 40: "*Cedrus* species ; cedar of Lebanon or allied species."

Sample E.—Wooden pegs from the door No. 23: " Possibly an *Acacia* species identity very uncertain in this case."

Sample F.—Part of a tongue from the boat : " Probably Mangifera indica."

The kinds of wood of the first five samples were obtained from trees which grew either in Egypt or in the countries near to it such as Lebanon or Western Asia. I was surprised, however, to find that the identification of sample F showed that it was probably of Mangifera indica, since as far as is known until now, this tree did not grow in Egypt anciently, and it is not probable that Egypt had commercial relations with India, the home of this tree, at that very early time. I wrote therefore to Dr. Werner to ask D. Phillips if he can kindly provide us with more details about this identification, because if it is assured, it will have a great significance from the archaeological point of view. Dr. Phillips kindly replied as follows :

"In view of the tentative nature of the identification in the case of sample F (Mangifera indica) I think we should re-examine the material before any final assessement is made of the archaeological significance of our finding in this case. The sample was returned to you so I cannot add much to my report: As far as I can remember the discernible structure of this sample fitted *Mangifera indica* fairly well but the structure of this species is not highly distinctive. If you can arrange for us to have the sample again or other material from the same part of the boat we will be pleased to investigate this".

It was not possible until now to send the sample again to the Forest Products Research Laboratory, because we are still collecting many other samples from the boat to send them to this Laboratory for identification, and this sample will be sent with them.

It is hoped that the identification of these samples will show that many other kinds of wood were used for the different parts of the boat. This may add a lot to what we already know about the kinds of wood used in Ancient Egypt and about its relations with the neighbouring or the far countries.

Many factors were taken into consideration by the Ancient Egyptians in choosing a certain kind of wood for making a certain part of the boat. These factors are for example hardness, durability, porosity, size, length, density, etc. All these points will be dealt with after we receive the identification of the different parts of the boat and know the function of each part after reconstructing it,

5.—Pigments used for Painting the Wood

Some of the side pieces of the boat, as well as two small rhomboidal boards, were painted white which proved to be of calcium sulphate (gypsum). The white paint on the rhomboidal board No. 3 was analysed in the Chemical Department, Cairo, and the following results were reported:

	%
Combined water	18.2
Loss on ignition	2.3
Insoluble in hydrochloric acid	1.1
Iron and aluminium oxides	0.1
Phosphorous pentoxides	traces
Calcium oxide	33.1
Magnesium oxide	traces
Sulphur trioxide	44.8
Chlorides (calculated as sodium chloride) ...	0.6
TOTAL	**100.2**

From these results the composition of the white paint was calculated as in p. 32.

COMPOSITION	%
Silica	1.1
Iron and aluminium oxides	0.1
Hydrated calcium sulphate	87.0
Anhydrous calcium sulphate	7.4
Calcium carbonate	3.1
Magnesium carbonate	traces
Calcium phosphate	traces
Sodium chloride	0.6
Fuel remains	0.9
TOTAL	**100.2**

It is observed in this composition that the percentage of the iron oxide is very small. If iron oxide was found in a high percentage, the gypsum paint would have acquired a yellowish or pinkish colour. This shows that the painters chose an exceptionally white sample of natural gypsum to be able to use it, after being heated and slaked, to obtain a clear white colour.

Since gypsum paint is easily removed if it remains in water for some time, it is quite probable that the boat never navigated in water-streams.

One piece of wood was painted red which proved to be of red iron oxide (red ochre), most probably mixed with an adhesive.

4*

6.—Joints

The numerous pieces of wood composing the boat were joined together by some means of which pegging, pegging and lashing, and dowels will be explained :

(a) *Pegging*.—Two holes were made in the two wooden pieces which were to be joined together. The two holes were then put opposite each other, filled with an adhesive paste, a wooden peg—slightly shorter than the depth of the two holes—introduced, and the excess paste pared away. The pegs are mostly of acacia wood.

Qualitative analysis showed that the adhesive paste was made of a mixture of ferric oxide and a nitrogenous organic adhesive. Sodium and potassium were determined by the use of a flame photometer in the Research Laboratory, British museum, London. The sample analysed proved to contain only 0.07% of sodium and 0.08% of potassium.

Being nitrogenous, the adhesive may be of glue. This was confirmed by Dr. A. E. Werner, Research Laboratory, London, who reported : "I have also examined the sample of adhesive that you left and can confirm that it is probably a *glue*—nitrogen test positive, and test for gum negative."

The ferric oxide used as a filler in the different samples of the adhesive paste examined is amorphous and of different colours. Ferric oxide is found in Egypt in the amorphous state as red ochre, yellow ochre, and brown ochre, It is interresting to point out that these kinds of ochre were used in the paste either separately or as a mixture of any two of them in order to match the colour of the wood for which the paste was used.

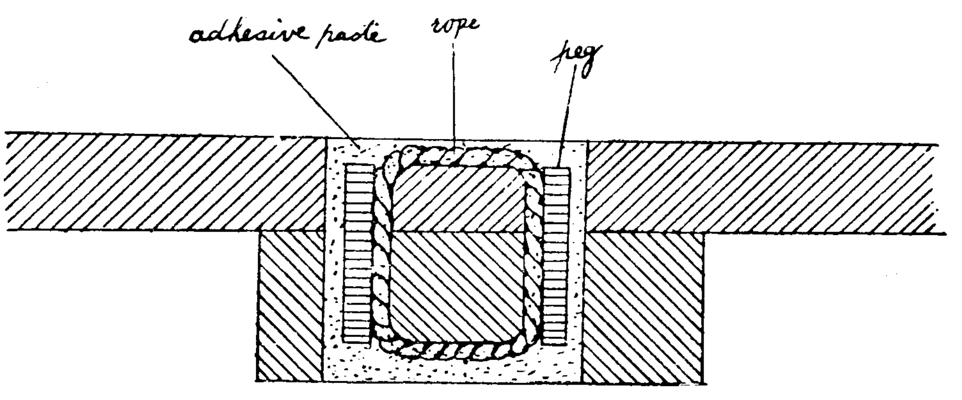

FIG. 15.—Section in the wood showing pegging and lashing.

(b) *Pegging and Lashing*.—In most of the cases of pegging made in the boat, two pairs of holes were made in the two pieces to be joined, a groove was carved in the wood between the two holes, a twine run round the holes for lashing the two pieces together, a peg introduced in each of the two pairs of holes, the groove filled with the same adhesive mentioned above, and the excess paste pared away (Fig. 15).

(c) *Lashing.*—Many pieces of the boat were lashed with ropes of halfa grasses alone or with the help of copper staples. Some ropes were found in their original positions in the boat lashing some pieces of wood together (Pls. XXXVIII, B and XLI, A). When stronger binding was needed, as in lashing the head of a column to a beam for example, a copper staple was hammered into the wood very near to the joint to pass in it the lashing rope to make the binding very tight and more efficient. Pl. XL, B shows one of these copper staples near the head of a palmiform column the top of which is concaved to fit well with a semi-cylindrical beam on lashing them together with the help of the copper staple.

This is the earliest case known to us in which copper was used in connection with joints for lashing wood. The earliest proper copper joints known, however, were found in the huge wooden sarcophagus and the wooden coffin of Amenemḥat of the Twelfth Dynasty. [1]

Besides the copper staples found in the boat used in connection with lashing, there are few others which served as eye-bolts in four of the five doors found in the boat.

One of the copper staples found in the long wooden beam No. 24 was examined physically and chemically by the following means :

(1) *Metallographic Examination.*—This was done in the "Laboratoire Central des Musées de Belgique, Bruxelles", during my visit to it in August 1956. Mademoiselle Goorieckx made a section for a small piece of the staple and prepared for it three microphotos (Figs. 16, 17, and 18) and reported the following :—

Fig. 16 Microphoto L. 2847 E. Coupe entière sans attaque, structure crousées, corrosion interne, patine interpénétrante du metal, gross. 41×

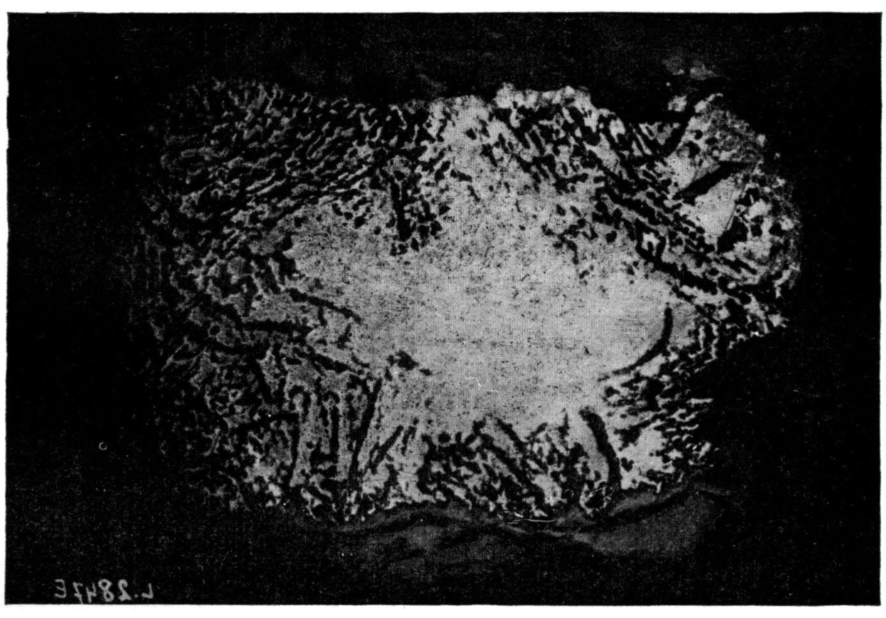

FIG. 16.—Microphoto of a section of a copper staple found in the piece No. 24.

(1) A. LUCAS, *Ancient Egyptian Materials and Industries*, 3rd Edition, 1948, P. 513,

Fig. 17. Microphoto L. 2848 E. Détail par attaque $CuCl^2$, structure dendritique fine du métal brut de coulée, gross. 88 ×

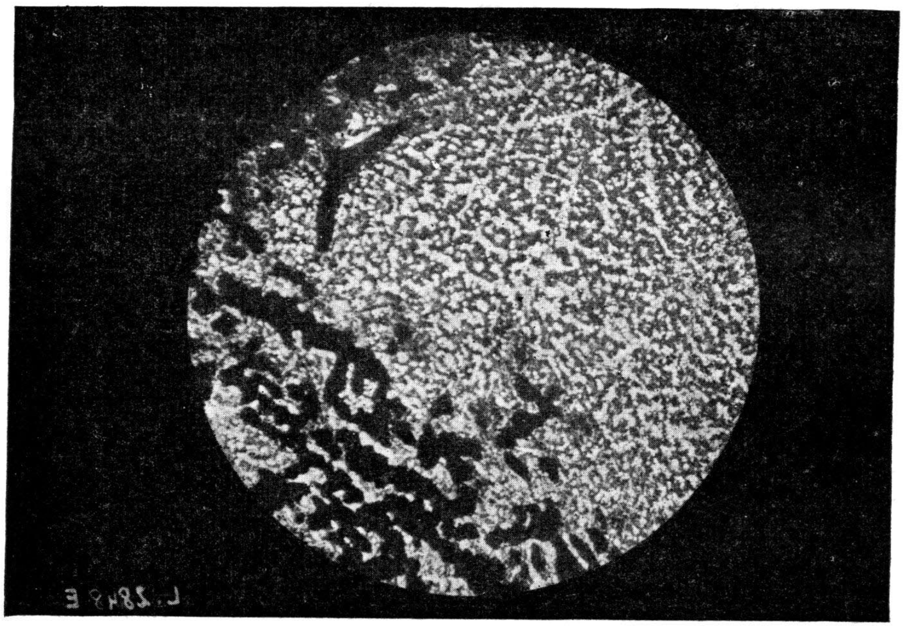

Fig. 17.—Microphoto of the previous staple showing details after treatment with copper chloride solution 88 ×.

Fig. 18. Microphoto L. 2849 E. Détail par attaque $CuCl^2$, la fragmentation de dendrites par écrouissage est révélée, gross. 259 ×

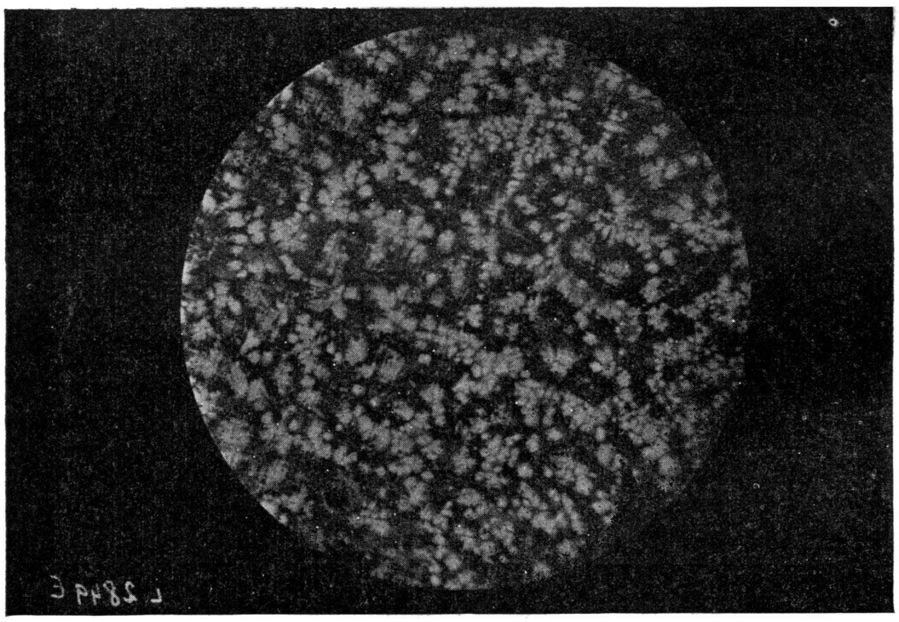

Fig. 18.—Microphoto of the previous staple, attacked by copper chloride solution : 259x.

(2) *X-Ray Diffraction.*—The general appearance of the staple indicates that it is of copper or bronze. In order to eliminate one of them, X-ray diffraction patterns were recorded on one film 8 × 8 cm. for a piece of pure copper, a piece of the copper staple under consideration and a piece of bronze (a Dutch cent containing about 10% of tin). The patterns obtained are shown in Fig. 19 which shows clearly that the lines obtained for the staple coincide fairly well with those of copper but not with those of bronze. This shows that the staple is of copper, but, since the lines obtained for the staple do not closely coincide with those of copper, the presence of other metals in small proportions as natural impurities was expected.

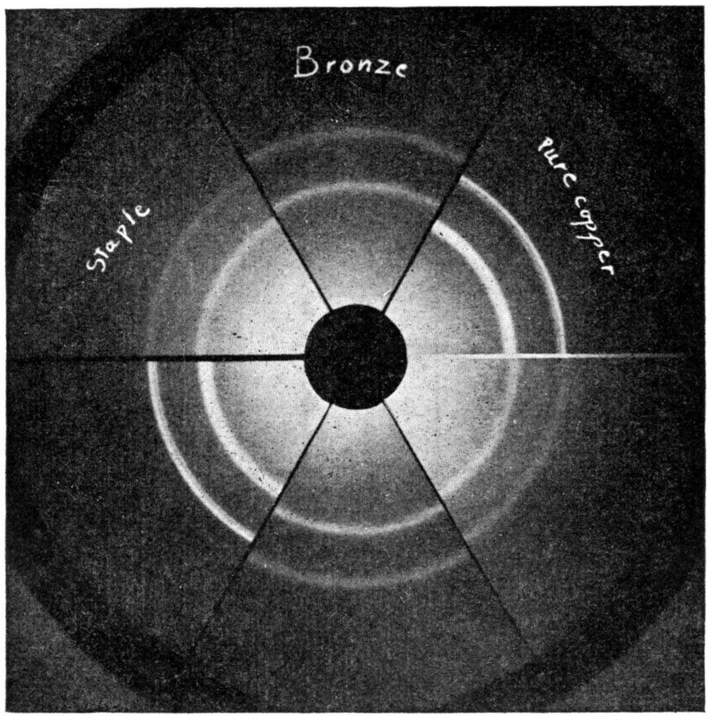

FIG. 19.—X-Ray diffraction patterns of a piece of pure copper, a piece of the staple, and a piece of brcnze

(3) *X-Ray Spectrochemical Analysis.*—In order to identify the metals found as natural impurities in the copper staple, its X-ray fluorescence spectrum was recorded (Fig. 20). From this curve, it is clear that the staple is mostly composed of copper and contains slight proportions of iron, zinc, and arsenic.

(4) *Microchemical Analysis.*—This was done in collaboration with Miss Bimson in the Research Laboratory, British Museum, London. Spectrophotometric analysis of a small piece of the staple showed it to have the following composition :

Copper	94.5
Arsenic	1.4
Iron	0.8
Zinc and oxygen (by difference)	3.3
TOTAL	**100.0**

Intensity Scale Counts/sec

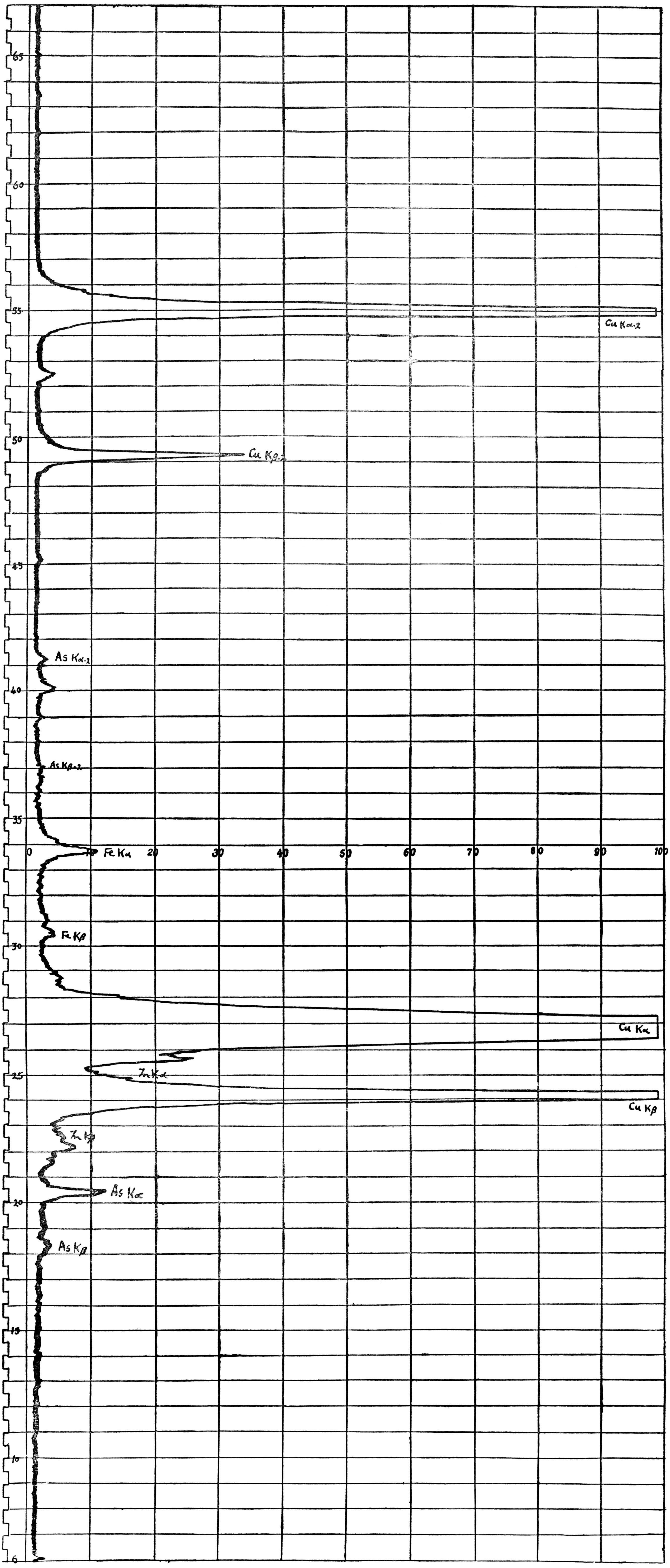

Fig. 20.—X-Ray fluorescence spectrum of a piece of a copper staple found in the long beam No. 24, 50 kv, 18 m A, × 16 × 1, 1° 1 cm./minute, time constant 2 seconds.

(d) *Dowels.*—Flat dowels of wood were used extensively in the boat to join the sides of the planks composing the many wooden boards found in it. These dowels were fixed in position with the same adhesive paste mentioned above (Fig. 21).

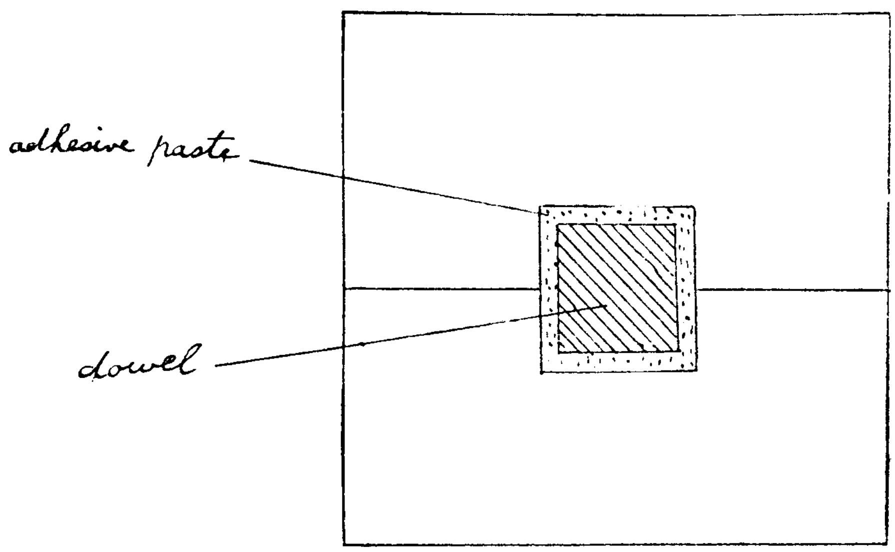

Fig. 21.—Section showing the use of flat dowels for joining adjacent wooden planks together.

7.—Conservation of the Objects Found on the Surface of the Boat

The matting, cordage, cloth, and, to some extent the fenders found on the surface of the boat were so friable that they were liable to fall into powder on touching them. It was necessary, therefore, to consolidate these objects with suitable preservatives before lifting them up. The conservation and lifting of these objects took about three months and the following procedure was adopted.

One photograph prepared for the whole surface of the boat in the pit (Pl. XLI, B) was divided into 63 squares, each corresponding to one square metre (Fig. 22). The important objects in these squares were given serial numbers, cleaned gently

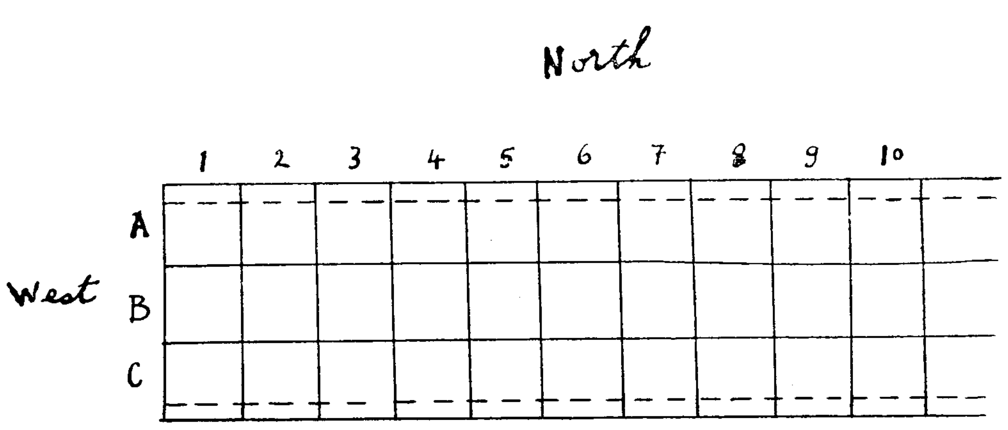

Fig. 22—Area of the pit divided into suitable squares.

with a stream of compressed air, photographed, treated with a suitable plastic solution (Pl. XLII), left to dry for one or more days, and lastly lifted up to the chemical laboratory on a suitable stand. In the laboratory, the preservation processes were completed, the loose or separate pieces stuck together, and the important descriptive details of every object recorded in a special card. The less important pieces of objects were kept, after treatment or without treatment, for scientific study.

The following table IV gives a summary of the objects conserved :

TABLE IV

Zone	The objects conserved	Their numbers
First Zone	11 Collections of several layers of mats ...	Nos. 1-11
Second Zone	5 Collections of two layers of mats	Nos. 12-16
Third Zone ...	9 Mats covered with cloth	Nos. 17-20, 22,23, 25-27
	1 Mat of Phragmites communis	No. 24
	2 Collections of ropes	Nos. 21, 35
Fourth Zone ...	3 Compact fenders	Nos. 28, 32, 39
	6 Dispersed fenders	Nos. 29, 30, 33, 34, 36, 37
	1 Rope	No. 31
Fifth Zone	3 Ropes (left in situ)	Nos. 40-42
	1 Mat of one layer of Typha leaves ...	No. 38

8.—Conservation of the Wooden Parts of the Boat

Although the wooden parts of the boat were mostly dismantled, they were found arranged in the pit in such a way as to give the outlines and features of a boat.

Realising that most of the parts of the boat were dismantled, it was decided to lift up the parts found in each layer separately. The same system used in lifting up the plant materials (p. 55) was followed here also. Thus one photograph was prepared for the whole layer, and this photograph divided into squares (Fig. 22) to be able to define the original position of each piece. The pieces were carefully lifted up from the pit and transferred to the restoration studio where they were described, description recorded in a special register and cards, and lastly treated for conservation.

Each piece was at first examined to record any scientific observations, as well as samples of the materials found on it, namely, adhesive paste, cloth, resinous matter, plant remains, etc. were collected. These samples were kept for investigation and analysis. It was then cleaned with an electric brush both by suction and blowing air, and treated with solutions of polyvinyl acetate or Bedacryl 122 × (I.C.I.). These solutions were applied with a spraying gun, by brushes, or by immersing the small pieces in them. The concentration of the solutions used and the number of coats applied depended on the state of preservation of the piece.

Markon Resin 9, low viscosity (Scott Bader and Co. Ltd, London) and its solution in acetone were used for the conservation of very disintegrated pieces. Markon resin mixed with saw dust was also used fo sticking some of the broken pieces together.

In almost all cases, the above solutions contained also 2% of para-dichlorobenzene and 2% D.D.T., as safeguard against insect attacks.

The wooden parts of the boat were found in 13 layers containing 651 pieces. Some of these pieces are very huge, for example there are 11 blocks whose dimensions ranged between 16.45 × 0.47 × 0.12 metres and 22.72 × 0.52 × 0.14 metres, and each weighing about one ton. Some of these, as well as many others, were fairly porous, and hence immencse quantities of the plastic solutions were consumed.

I have great pleasure in thanking my colleagues Mr. Victor Girgis Awadallah, Mr. Abd El-latif Erfan, and Mr. Abd El-Ghani El-Dibawi of the staff of the Chemical Laboratory, Dept. of Antiquities, for their effort in the conservation of the objects mentioned above. My thanks are also due to Mr. Hassan Zaki for preparing most of the photographs needed for this publication.

ZAKY ISKANDER

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List of Figures

List of Plates

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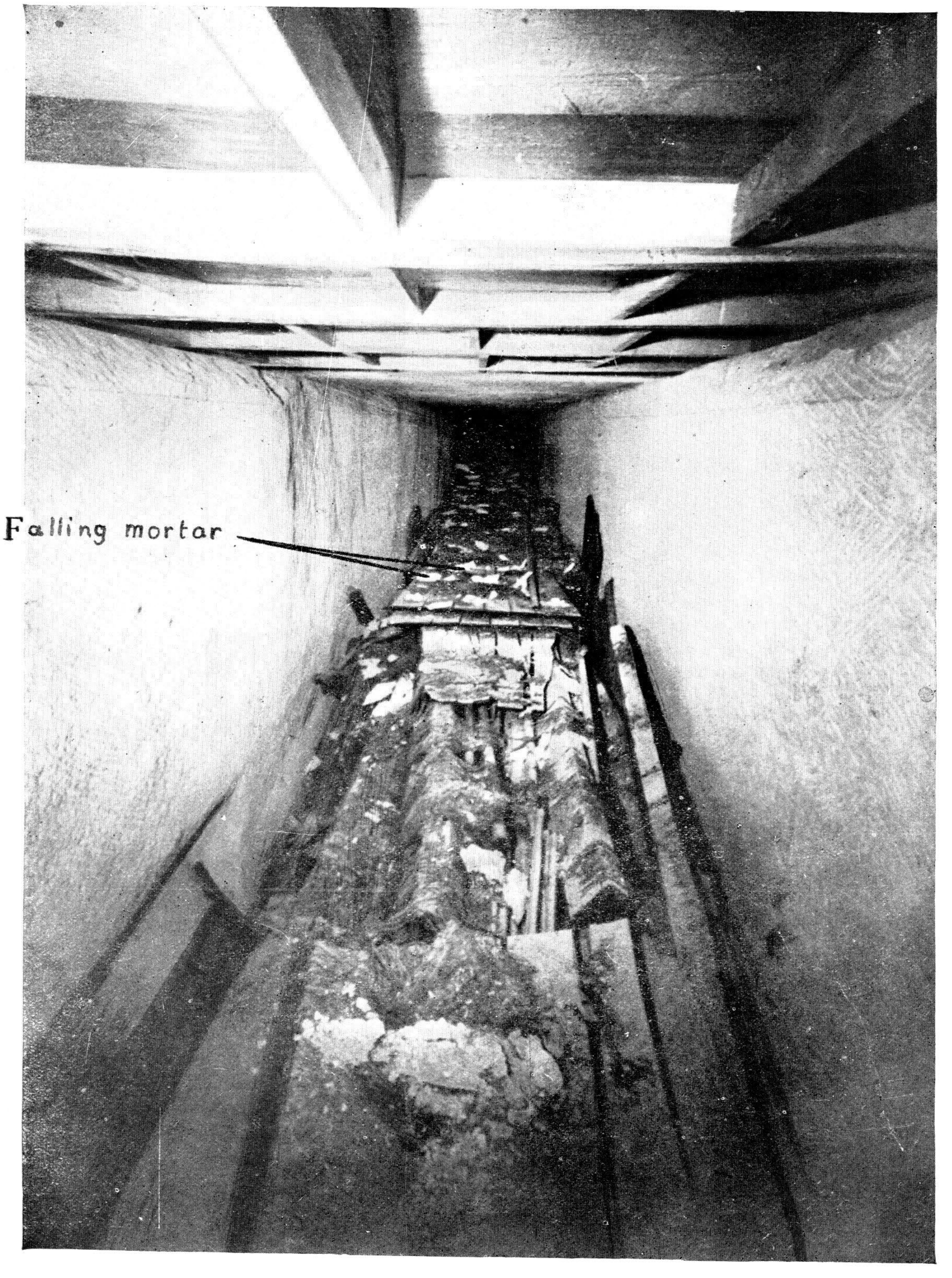
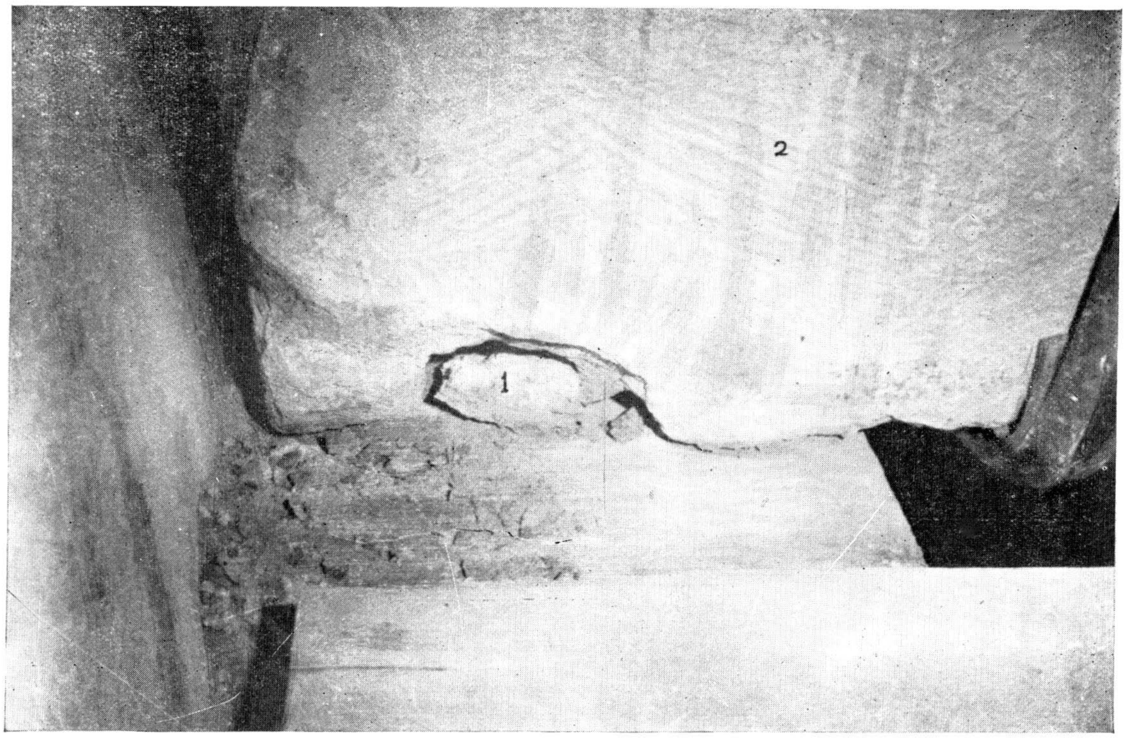
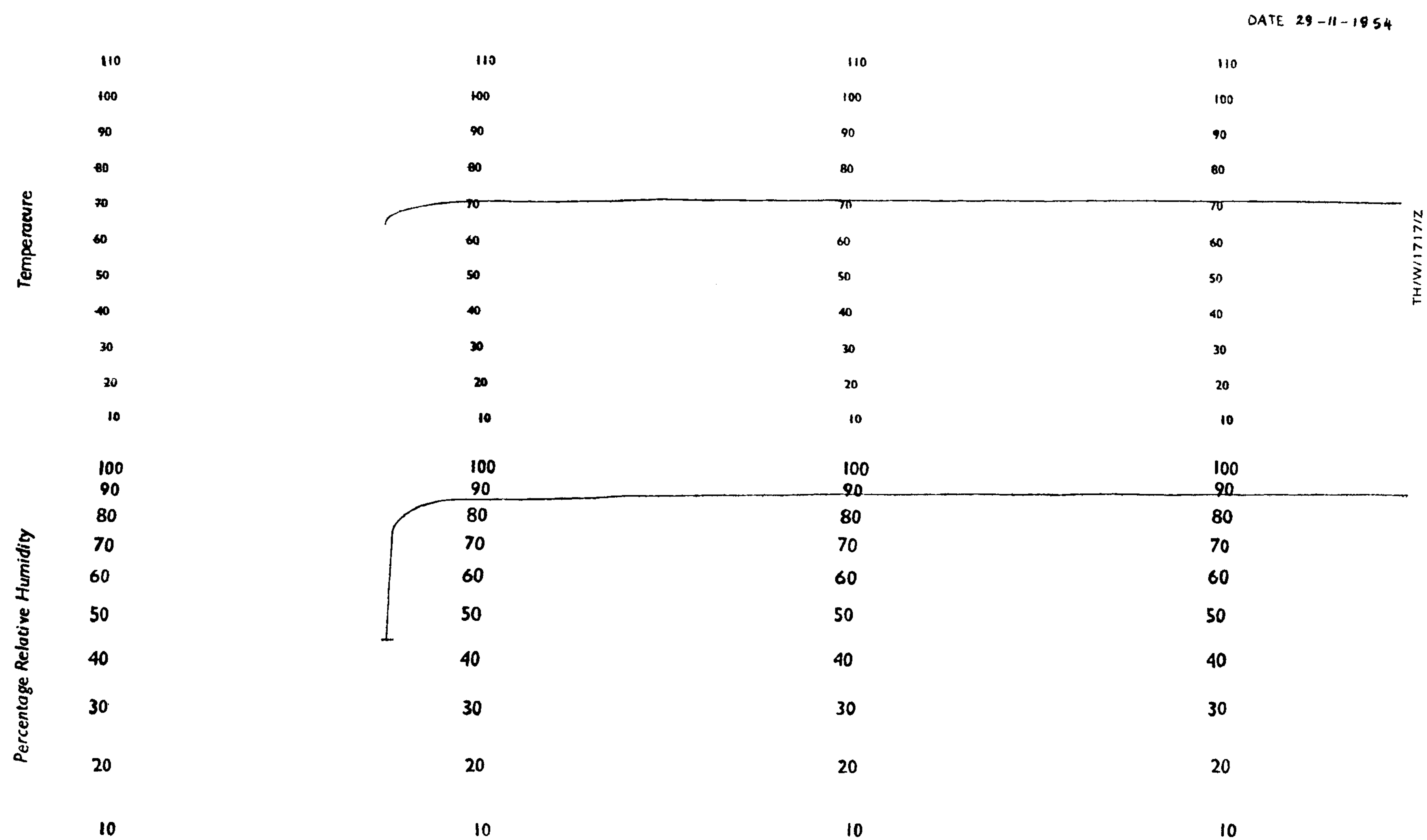


The surface of the boat as seen in the pit from west to east showing many pieces of gypsum mortar falling on the matting and the wood. In the upper part of the picture are seen the wooden boards used to cover the pit after lifting up the blocks.



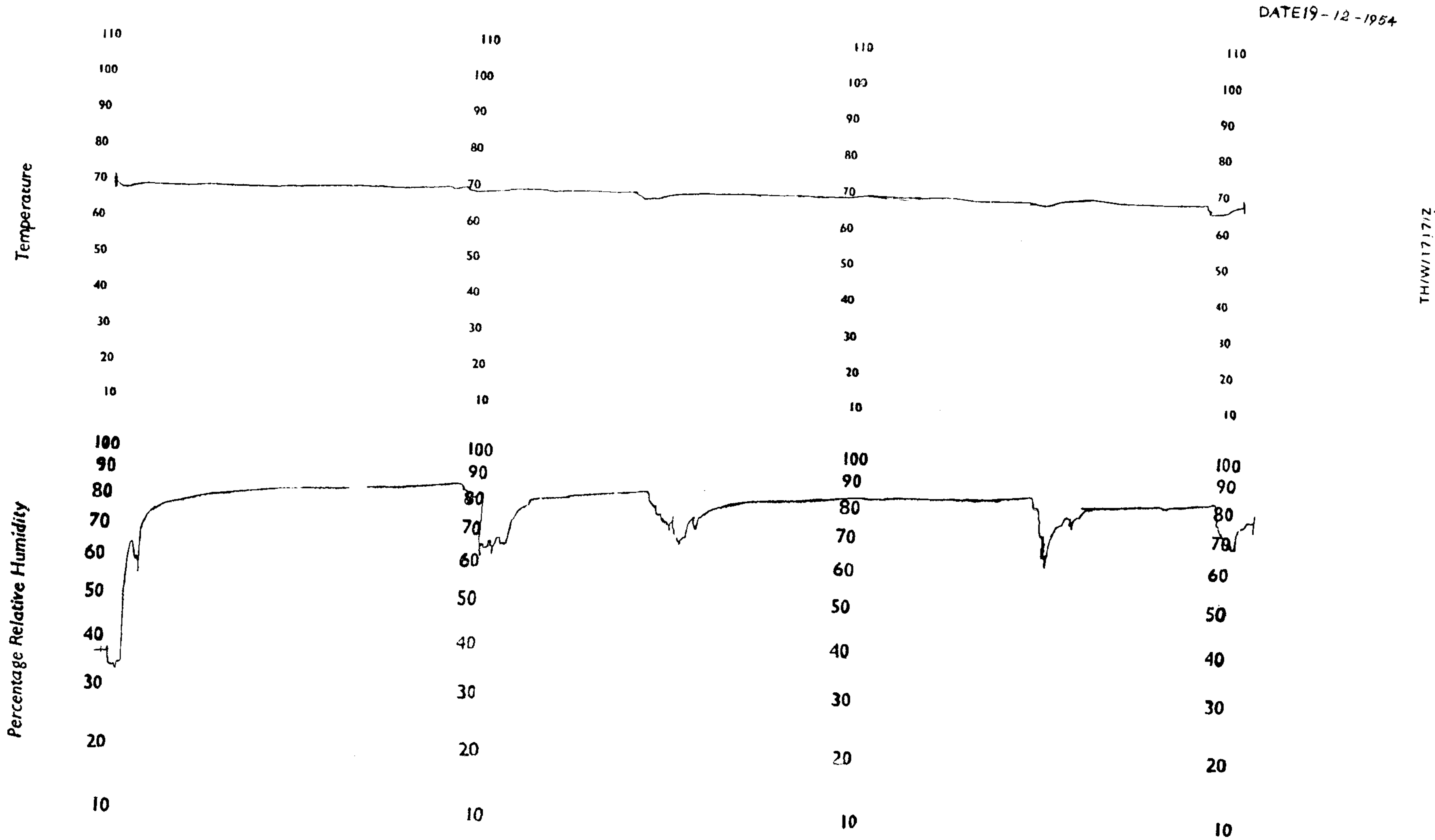
A.—Part of the north west corner of one of the blocks showing:
(1) The northern semi-circular opening filled with gypsum mortar. (2) The trickling down of the thin gypsum mortar which was poured from above to fill the small spaces between every two adjacent blocks.

B.—Ropes which were lying under the collection of mats No. 7 and hanging downwards.



Graph showing the temperature and percentage relative humidity inside the pit from 23rd to 29th November 1954.

Pl. XXXIII

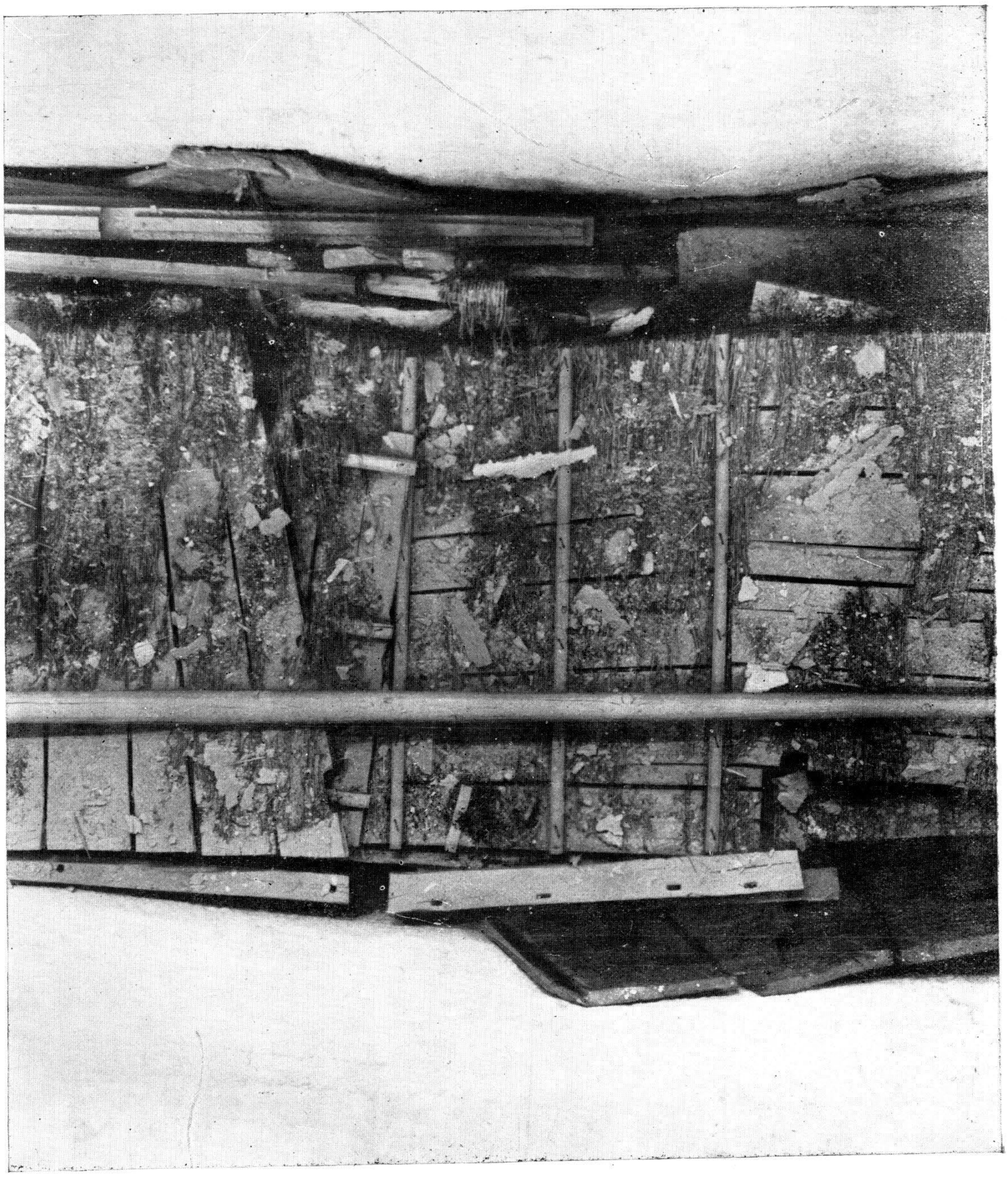


Graph showing the temperature and percentage relative humidity inside the pit from 13th to 19th December, 1954.

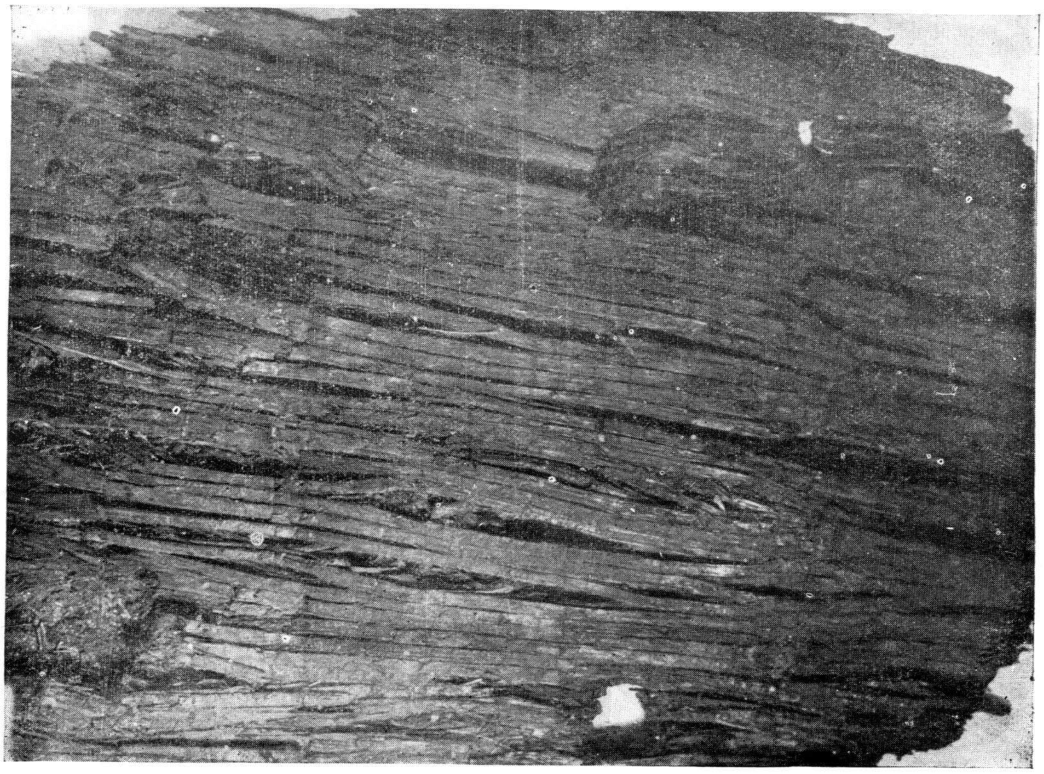
Pl. XXXIV

Collection of matting composed of 3 mats, the upper and lower are of Typha australis leaves sewn together with threads and the middle of interwoven slices of Juncus culms (after being treated and transferred to the laboratory).

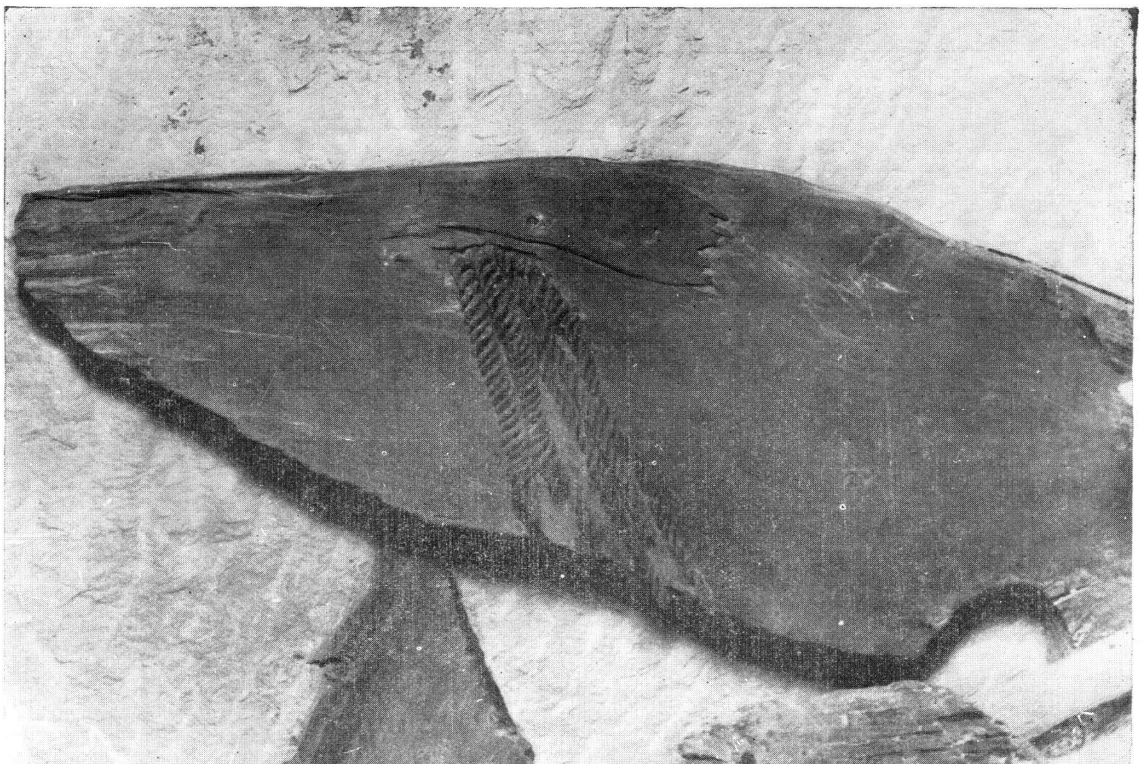
A collection of two layers of mats, the upper of interwoven slices of Juncus culms and the lower of Typha australis.



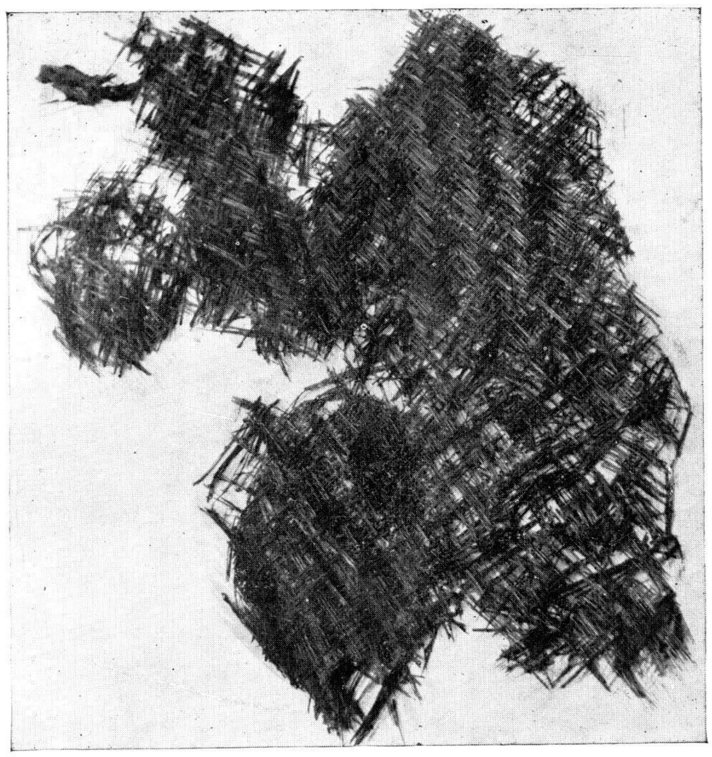
Part of the third zone which was mostly covered with one layer of matting of Typha australis leaves, over which was spread a layer of cloth.



A.—The back surface of a mat from the third zone (after being chemically treated and lifted up). It is made of Typha australis leaves which are sewen together with threads.

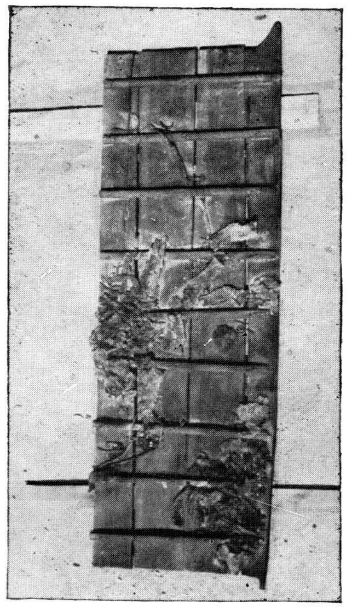


B.—A collection of 5 two-strand ropes used for lashing.

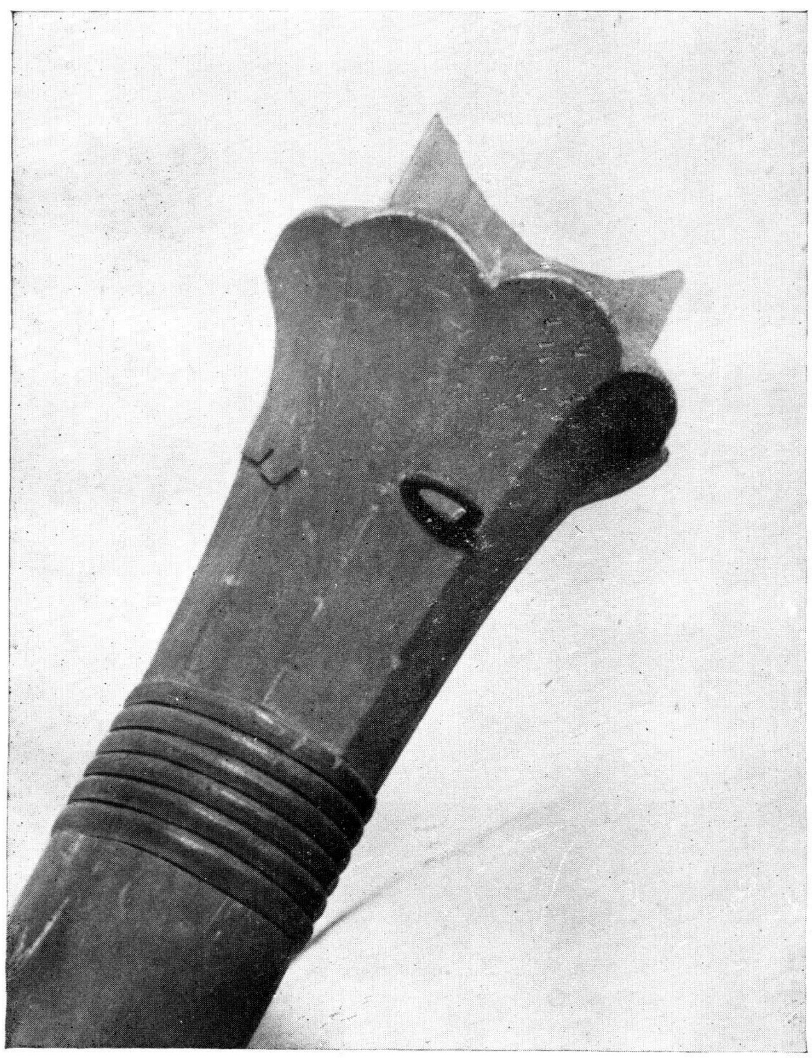


A.—Mat No. 24 made of interwoven culms of common reed.

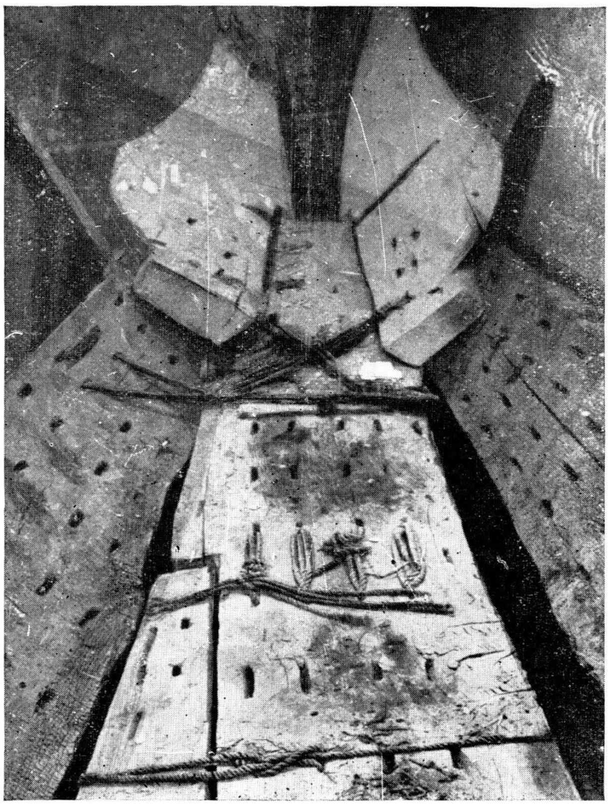
B.—Fender No. 28.



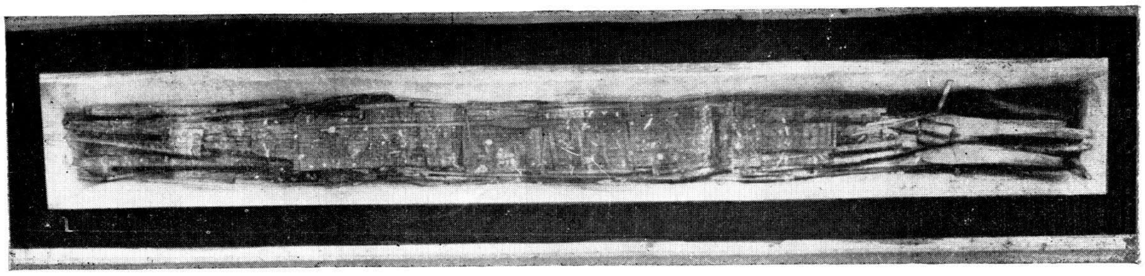
A.—Remains of two dispersed fenders (Nos. 29 and 30) found on one of the doors.



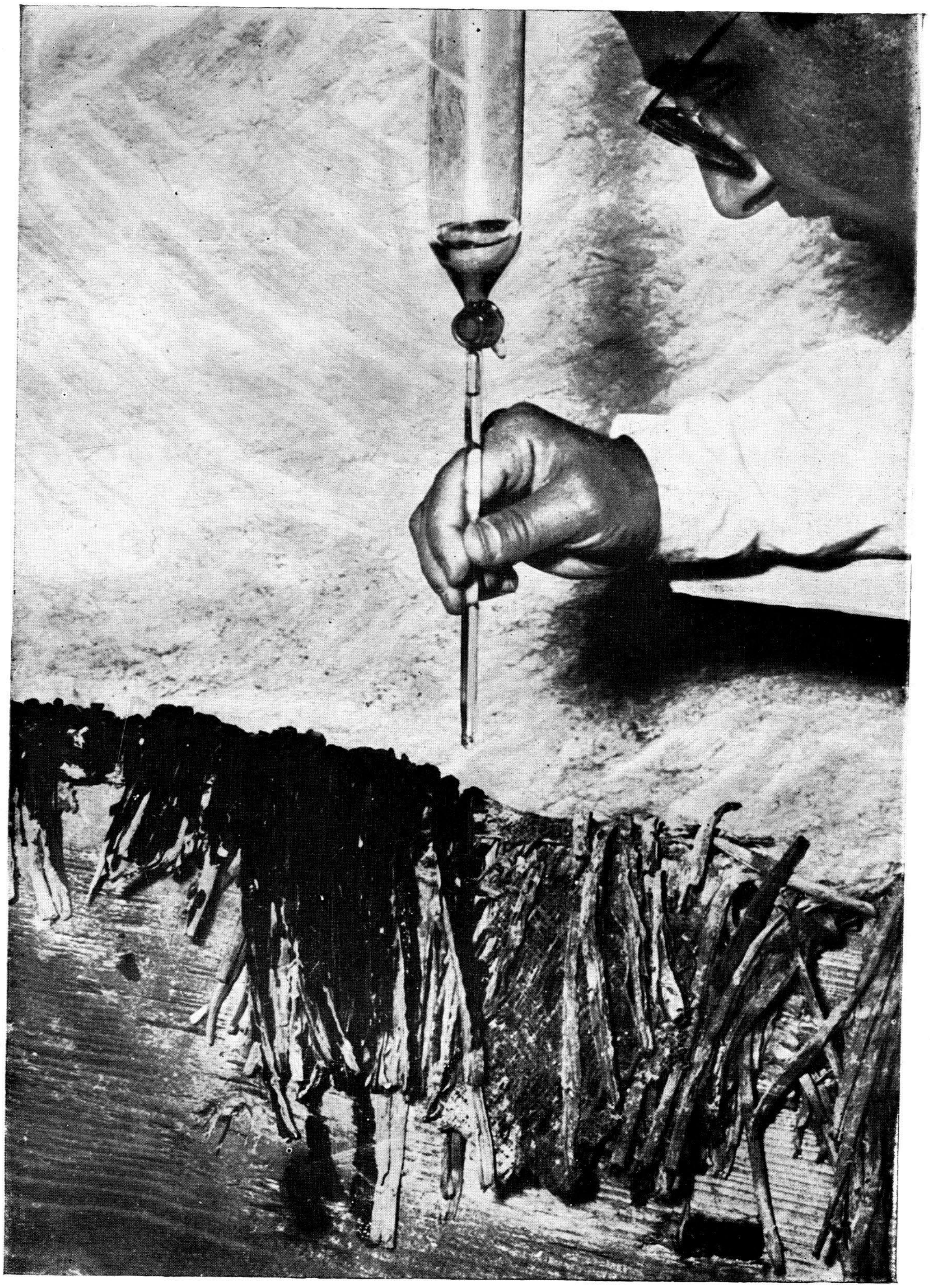
B.—The upper part of a palmiform column near the top of which there is a copper staple to strengthen the lashing.



A.—Some ropes used for lashing, still in their original position.



B.—One photograph for the whole surface of the boat before lifting up the plant remains.



Treatment of a collection of mats with a solution of polyvinyl acetate in situ.

THE LIFTING UP OF THE WOODEN PARTS OF THE GIZA BOAT

BY

AHMAD YOUSSOF MOUSTAFA

INTRODUCTION

In May 1954, the Department of Antiquities discovered a great boat to the south of the Great Pyramid at Giza. Its parts were found dismantled in a pit cut in the rock. The pit was about 31.2 m. long, 2.6 m. wide and 3.5m. deep. It was covered with 41 blocks (each about 4.5 × 0.85 × 1.6 m.) which were arranged one close to the other (Pl. XVII, A). The wooden parts of the boat had been safely kept under this close cover for about 4700 years.

These wooden parts were found heaped up in the pit to about two thirds of its height. On the top of these heaps, were found the remains of mats, ropes and other materials. The Chemical Laboratory was charged with the chemical treatment and the lifting up of these remains (*see* the Scientific Report, p. 55), and to keep them for exhibition after reconstructing the boat (Pls. XLIII - XLV).

A building was constructed as a restoration studio beside the pit of discovery. It was planned to be wide enough and suitable for keeping safely, repairing and reconstructing the wooden parts of the boat.

On December 17th 1955, started the work of lifting up the wooden parts of the boat from the pit to the restoration studio. The Department thought better that the curator of the Pyramids' region, the director of the Chemical Laboratory, and the chief of the Restoration Section, should co-operate in this work.

The curator of the Pyramids' region cooperated with the director of the laboratory in describing in detail every piece of the boat directly after lifting it up from the pit to the restoration studio This description was recorded in a special register in Arabic and in cards in English. The director of the chemical laboratory was also concerned with treating the wooden parts of the boat chemically to prevent their decay. I was charged with lifting up the pieces from the pit and transferring them to the restoration studio where they will be repaired and reconstructed.

After consideration, it was agreed on several steps for the work each dependant on the completion and success of its precedent. These steps are :

1.—Photographing the parts before lifting them from the pit.

2.—Reaching the surface of the pieces without being supported on them.

3.—Protecting the weak parts before lifting them.

4.—Lifting up the wooden parts of the boat from the pit and transferring them to the restoration studio.

5.—Arranging the parts of the boat in the studio.

This report shows how these steps were fufilled illustrated mostly by photographs. These photograghs had been taken by myself except those in Pls. XLIII-XLVI which were copied from photographs taken before my participation in the work. At the end of the report, I give a brief description of the ropes and strange materials that were found with the wooden parts of the boat.

1.—Taking photographs of the wooden parts before lifting them from the pit.

The wooden parts of the boat had to be photographed for two purposes. The first was to register the surface of all the visible parts of every layer in one single photograph to show the position of each piece in relation to the others. The second was to photograph every part of the boat separately and register its condition before lifting it.

In the first case we were faced by the difficulty of not possessing a camera to photograph the whole layer, being more than 30 metres long and 2.5 metres wide, in one single paragraph as a horizontal projection at a short distance. Mr. Hassan Zaki, the photographer, got over this difficulty by moving his camera on rails at a constant distance over the pit from one end to the other and taking several photographs at a fixed angle and of the same measure. These photographs were stuck together to make a photograph of the whole surface of the layer. This process had to be repeated for the thirteen layers which constituted the boat. Pl. XLVI shows the surface of the first layer of the boat in the pit after lifting up the remains of matting, ropes, etc. from it and cleaning it from the debris that fell on it.

For the second purpose, I had to undertake photographing each piece separately to be able to study the order of the different parts and put down any remarks which may help me in repairing and reconstructing the boat. Pl. XLVII shows some of the separate pieces, Pl. XLVIII shows the situation of some pieces in relation to the others.

2.—Reaching the surface of the pieces without being supported on them

The distance between the surface of the first layer of the boat and the pit-head was about 1.5 m. It was necessary ot reach this surface without being supported on it. For this purpose, we had to hang in the pit a scaffold which could be moved without touching the surface of the boat. It was composed of two wooden beams 5×4 inches lying 3.5 metres apart, across the pit. Two linen ropes 1.5 inches in diameter, were tightly fastened near the ends of these two beams. They were planned to be about 20 cms. higher than the surface of the pieces to be lifted. In these ropes were tied two wooden boards each shorter than the width of the pit by about 10 cms. On these boards, and inside the ropes hanging from the beams, were put two other boards parallel to the length of the pit, each 4 metres long. A ladder was then lowered from the pit-head supporting on one of the longitudinal boards and leaning on the wall of the pit. This scaffold could be moved from one place to the other along the pit-head. Pl. XLIX, A represents the skeleton of the scaffold hung inside the pit, Pl. XLIX, B shows each part separately and how they are put together.

3.—Protecting the weak pieces of the boat while lifting them from the pit

On examining the wooden pieces of the boat before lifting them from the pit, we found that they differed greatly in shape and size. Some of them were in such a bad condition that they might fall into smaller fragments during lifting them up. For the safety of such pieces, strong crossbeams were put directly under the weak pieces as supports which were fixed to the northern and southern walls of the pit by small wooden pegs. This quick precaution helped us to preserve the weak pieces and enabled us to lift them safely. Pl. L, A, shows the wooden supports beneath the pieces of the boat as seen from above, Pl. L, B shows the same supports between the pieces.

4.—Lifting up the wooden parts of the boat and transferring them to the Restoration Studio

Before starting, the photograph of the whole surface of the upper layer was divided into squares. Each one was given a special number and an alphabetic letter to help in determining the place of each part in relation to the other (Pl. LI).

The parts of the boat had been lifted up and transferred to the restoration studio by two means: the first, by hand for lifting up the flat pieces; the second by the crane for lifting up the large wooden blocks. These two means will be explained by considering five examples which will illustrate the different procedures followed in this process.

Example I.—*Lifting up the flat pieces.*

As an example for this we are going to explain how we managed to lift up the wooden door No. 59. It is 216 cms. long and 75 cms. wide. Its position in the photograph (Pl. LI) is 22-24 (B). It had been photographed separately to record its condition before lifting it. (Pl. LII, A).

The wooden scaffold was put so as to be little higher than the door in the pit. The door was then inserted between crossbeams of suitable size taking care to keep it in a horizontal position. The crossbeams were tied with ropes by which the door could be lifted up-between the crossbeams - to the pit-head. This process was carried out in the space between the two boards of the scaffold (Pls. LII B, LIII A and B).

Pl. LIV shows the door at the level of the pit-head. The workers are standing on broad wooden boards put on both edges of the pit as a bridge, ready to carry the door to the restortion studio. When the door was carried to the studio, it was given a serial number and labelled with a small card containing preliminary information on this part of the boat. It was then treated chemically to protect it from insects or anything that might cause its decay. Finally it was recorded in the special register in Arabic and in cards in English.

Example II.—*Lifting up the broad flat pieces.*

In case the broad flat pieces could not be passed through the boards of the scaffold (as in the previous example), we had to change the position of the longitudinal boards of the scaffold. Instead of the first position being close to the door from outside, the longitudinal boards were moved slightly to the inside over the two sides of the broad part. Then the piece was inserted between crossbeams of suitable size as in example I. The ends of the crossbeams were tied with ropes outside the longitudinal boards of the scaffold. These boards were then removed and the piece (between the crossbeams) was lifted up by the ropes to the upper level of the pit, transferred to the restoration studio, treated chemically and its description recorded in the register. Pl. LV illustrates how this proceeding was carried out.

The large pieces were composed of many pieces most of them were loose and so weak that it was very difficult for the workers to carry them safely to the restoration studio. To facilitate the work and as a further precaution for the protection of the weak parts of the piece at the same time, it was necessary to put a wooden board transversely across the double bridge to act as a support for the piece immediately after it reached to the bridge. Thus it was easy to carry the piece on this board in a safe horizontal position to the studio without changing the order of the weak pieces. Pl. LVI illustrates this proceeding of supporting a large piece on the board.

Example III.—*Lifting up the large parts which are longer than the scaffold.*

In lifting the large parts which are longer than the normal length of the scaffold, we had to lengthen the skeleton of the scaffold by repeating the unit composed of the beam and the short board hanging from it. Then the units were fastened together by longitudinal boards so that the scaffold might become long enough for the part in question as seen in (Pl. LVII, A).

The piece was then inserted between crossbeams of suitable length as before. These crossbeams were fastened from both sides in different places along the piece. The ropes were fixed at the pit head. The scaffold was then completely removed and the workers lifted up the piece by the ropes fixed on the pit-head (Pl. LVII, B).

EXAMPLE IV.—*Lifting up the large wooden logs.*

Fpr lifting up the large wooden logs from the pit by the crane, Mr. Taha-el-Sheltawi, chief architect of the Department, thought it necessary to prepare a long iron beam suitable for the length of the wooden logs. To insure the distribution of the weight of the log on its length, and to insure the counterbalance of the log when lifted up, the iron beam was attached to the hook of the crane. This proved to be a very successful process which facilitated the job a great deal. It was carried out as follows :

The crane was hung from a dolly truck which moved easily on rails in the roof of the wooden shelter and the iron beam which was 15 metres long was tied to the hook of the crane. At equal distances along this iron beam were hung several ropes which were used in tying and pulling up the logs. To prevent the ancient wood from being damaged by the ropes, a thick piece of felt was intercalated between the ropes and the log (Pl. LVIII).

Owing to the great weight and the great size of the log, we had, in tying it with the ropes, to use a lever and a wooden support to raise the piece enough to put a small beam of wood so that the rope could be passed through.

After tying the log with the ropes hanging all along the iron beam, it was lifted by the crane to the pit-head. Wooden boards were then put under the log, covering the pit and acting at the same time as a ground for the labourers to stand upon on untying the log away from the iron beam and carrying it to the restoration studio. Pls. LIX and LX illustrate how this proceeding was carried out.

EXAMPLE V.—*Lifting up the weak and cracked pieces.*

One of the huge wooden logs was found so much cracked that it was difficult to lift it up safely without making additional precautions. Wooden boards of suitable length were, therefore, clamped above and under the cracked parts in such a way that the log and the boards might become one single piece which could be lifted up in the same way as in the previous example. Pl. LXI, A shows one of the cracks, Pl. LXI, B illustrates how the wooden boards were clamped in the log, and Pl. LXII shows how the piece was lifted up inserted between the wooden boards. It illustrates clearly how the iron beam was hung in the book of the crane and how the piece was tied with ropes along the iron beam.

After removing the wooden logs, we noticed that they were supported on stones put in the bottom of the pit to protect the curves and forms of the huge logs of the boat when piled up in the pit.

Number of the part of the Boat.

The parts of the boat lifted up from the pit were 407. These parts were composed of 651 wooden pieces arranged in thirteen layers, one over the other. The following is a detailed account of the layers and their contents :

1st layer	: parts from No.	1 to No.	42	containing	47 pieces
2nd layer	: parts from No.	43 to No.	49	containing	7 pieces
3rd layer	: parts from No.	50 to No.	58	containing	10 pieces
4th layer	: parts from No.	59 to No.	79	containing	22 pieces
5th layer	: parts from No.	80 to No.	85	containing	6 pieces
6th layer	: parts from No.	86 to No.	90	containing	5 pieces
7th layer	: parts from No.	91 to No.	100	containing	10 pieces
8th layer	: parts from No.	101 to No.	104	containing	4 pieces
9th layer	: parts from No.	105 to No.	167	containing	63 pieces
10th layer	: parts from No.	168 to No.	183	containing	16 pieces
11th layer	: parts from No.	184 to No.	210	containing	30 pieces
12th layer	: parts from No.	211 to No.	263	containing	53 pieces
13th layer	: parts from No.	264 to No.	407	containing	378 pieces

(1) No. 31 contains 15 poles and No. 32 contains one piece and a pole.

(2) No. 55 bis is composed of two wooden pieces forming T—shape on the original piece.

(3) No. 60 bis is a latch-in the form of an elater-which was found on the board No. 60

(4) No. 192 is composed of four pieces A.B.C.D.

(5) No. 443 three pieces, No. 361 bis, No. 362 bis, No. 363 four pieces, No 365 five pieces, No. 375 eight pieces, No. 378 twenty pieces, No. 379 seven pieces, No. 380 four pieces, No. 382 three pieces, No. 384 seven pieces, No. 385 seven pieces, No. 388 six pieces, No. 390 17 pieces, No. 391 four pieces, No. 392 eleven pieces, No. 394 four pieces, No. 395 twelve pieces, No. 396 six pieces, No. 397 thirteen pieces, No. 398 thirteen pieces, No. 399 five pieces, No. 400 ten pieces, No. 401 twenty pieces, No. 402 fourty pieces, No. 406 seven pieces, No. 407 three pieces.

Ancient ropes and other materials found with the wooden parts of the Boat.

Many ancient ropes were found with the boat in the pit. These ropes are of three different thicknesses ; their diameters being about 1.0, 1.5 and 2.0 cms. respectively. Few of these ropes were used for lashing some of the wooden parts (Pl. LXIII, A), some were thrown between the different layers (Pl. LXIII, B), and others were heaped up at the bottom under the wooden parts (Pl. LXIV).

We should mention that when all the wooden parts of the boat had been lifted up, we found, at the bottom, collections of small wooden pieces of different shapes. They were made in bundles thrown carelessly. Pl. LXV, A shows some of these collections ; Pl. LXV, B shows how the bundles were tied with ropes.

On the ground, under both the wooden pieces and the ropes, there was a small piece of flint in the shape of a knife or a chisel ; beside it, there was another piece of black granite of no definite shape. These were the only objects found in the pit besides the ancient wood and ropes.

5.—How the Parts of the Boat were aranged in the Restoration Studio

To arrange the wooden parts of the boat in the restoration studio, we drew a sketch of the analogous parts in every layer separately according to their original places in the pit. In accordance with this sketch and the place of each part as shown on the general photographs of the layers, wooden shelves suitable for the size of the pieces were made. Upon these shelves the pieces of the boat were arranged as far as possible in the order in which they were found in the pit. Pl. LXVI, A shows the sketch and the similar parts in the consecutive layers. Pl. LXVI, B shows the wooden shelves on which the pieces were arranged. Pl. LXVII shows almost all the wooden parts of the boat in the studio after lifting them up from the pit. This process had been accomplished during the period from December 17th, 1955 to July 5th, 1957.

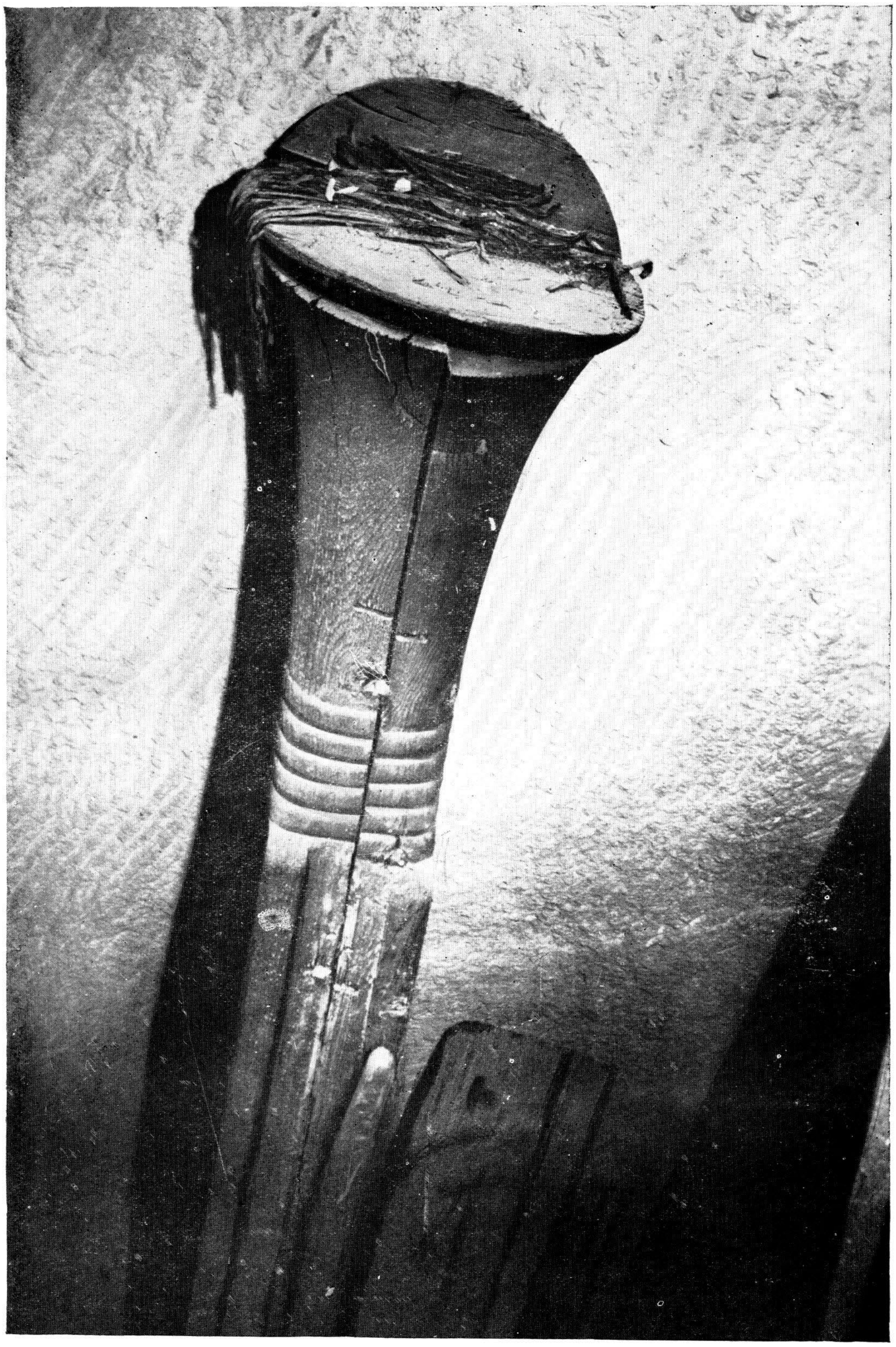
A. Y. Moustafa

List of Plates

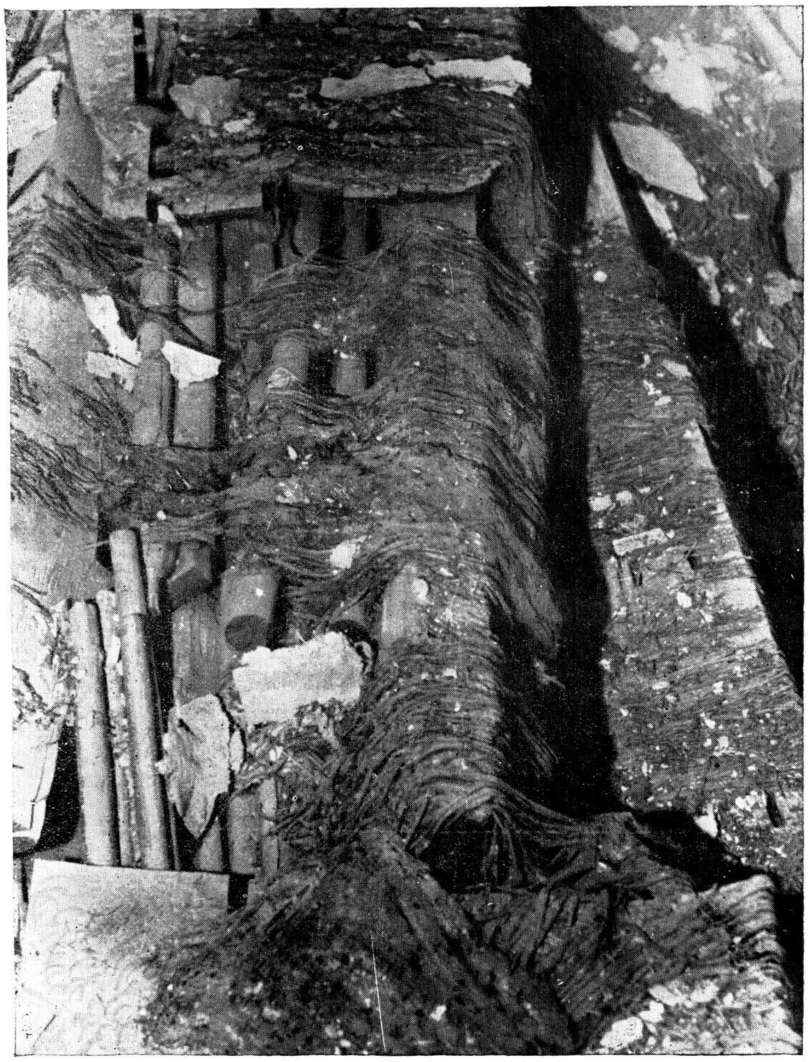
Pl. XLIII

A.—The parts of the boat as seen from west to east, photographed from the hole made in the 22nd block.

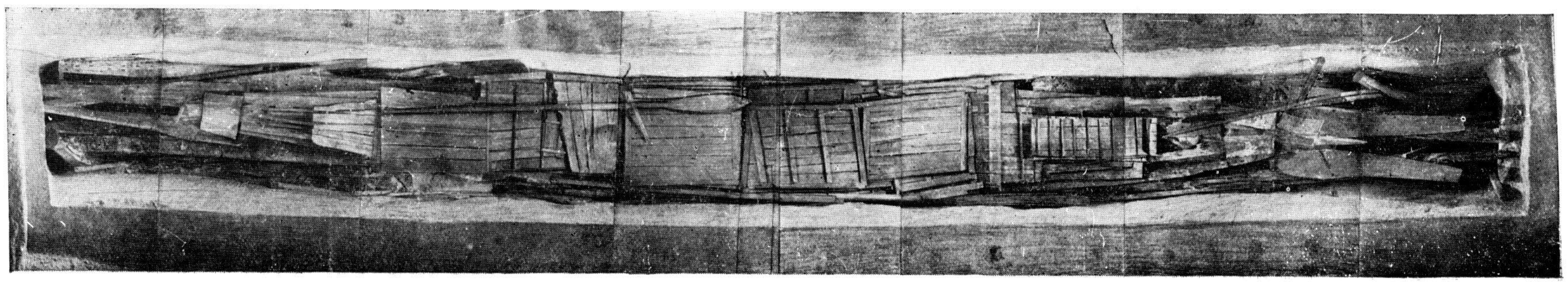
B.—Another side-view of the parts of the boat from east to west. In the further-most edge of the photograph the prow of the boat is seen. Photographed from the hole made in the 22nd block.



The prow of the boat in the shape of a bundle of papyrus stalks. Chisel marks are apparent on the side of the pit behind the column.

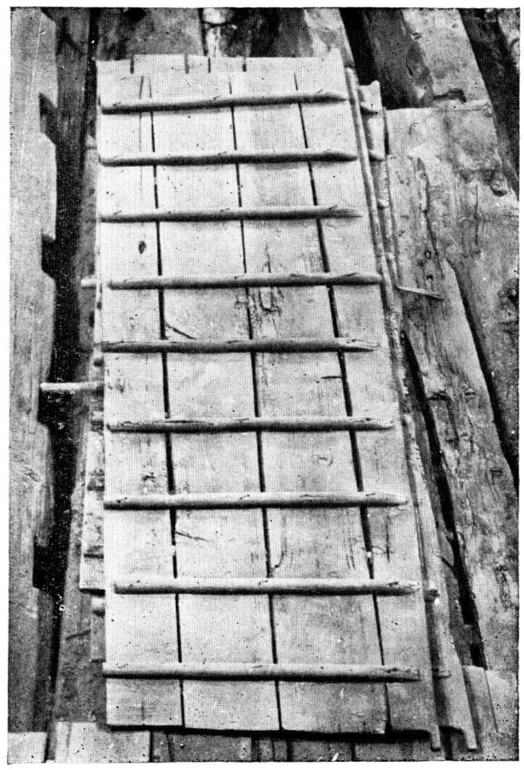


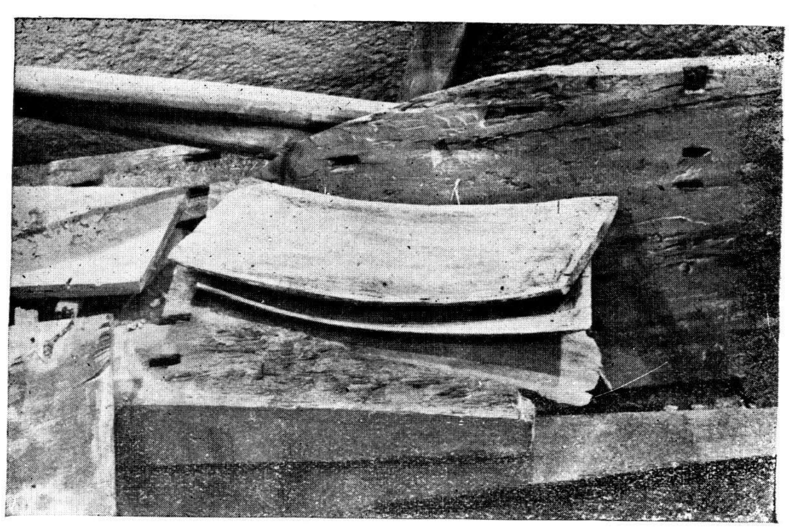
Some of the mats, and other materials that covered the wooden parts of the boat.



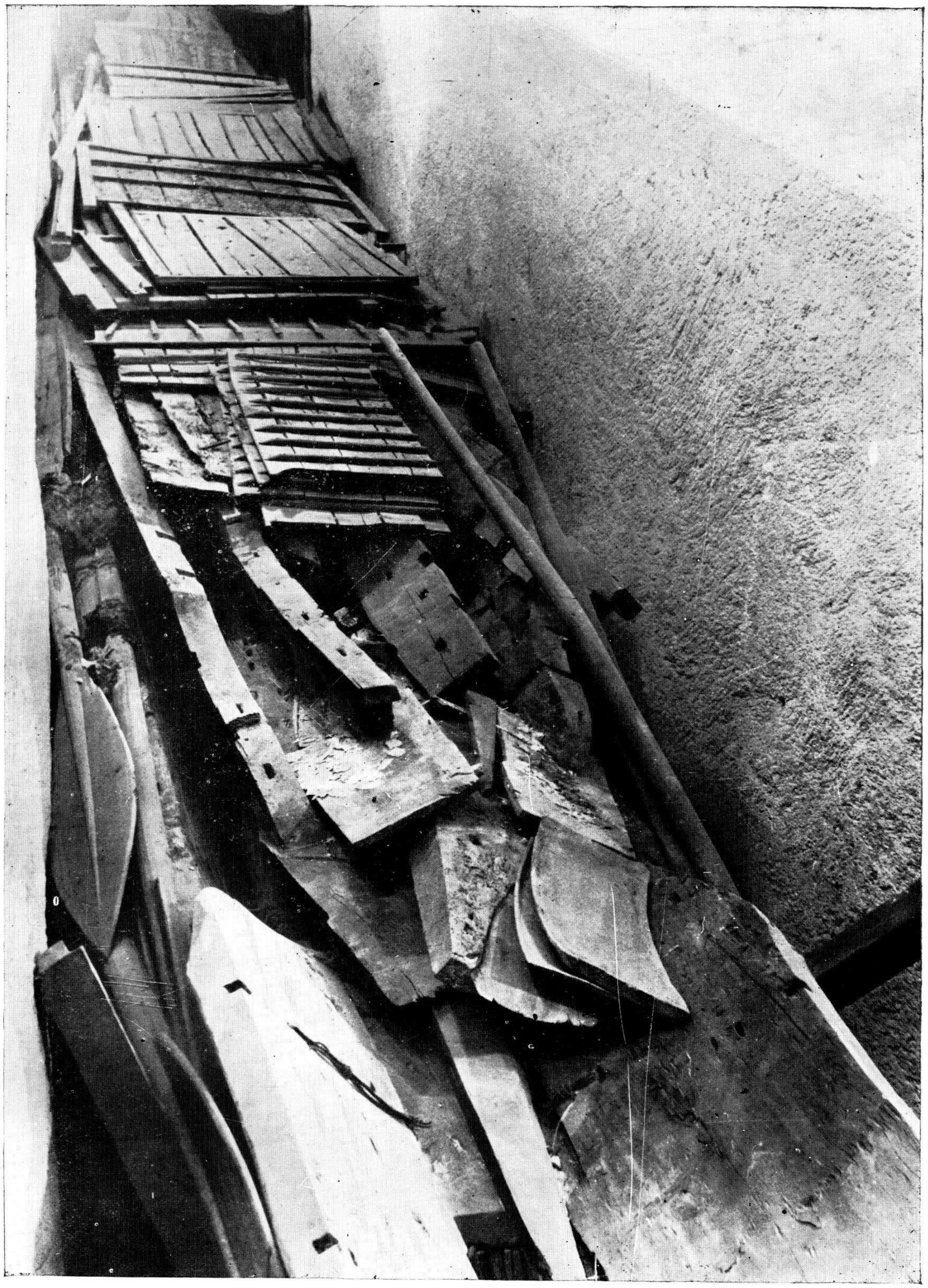
Photograph of the first layer of the boat.

Pl. XLVI



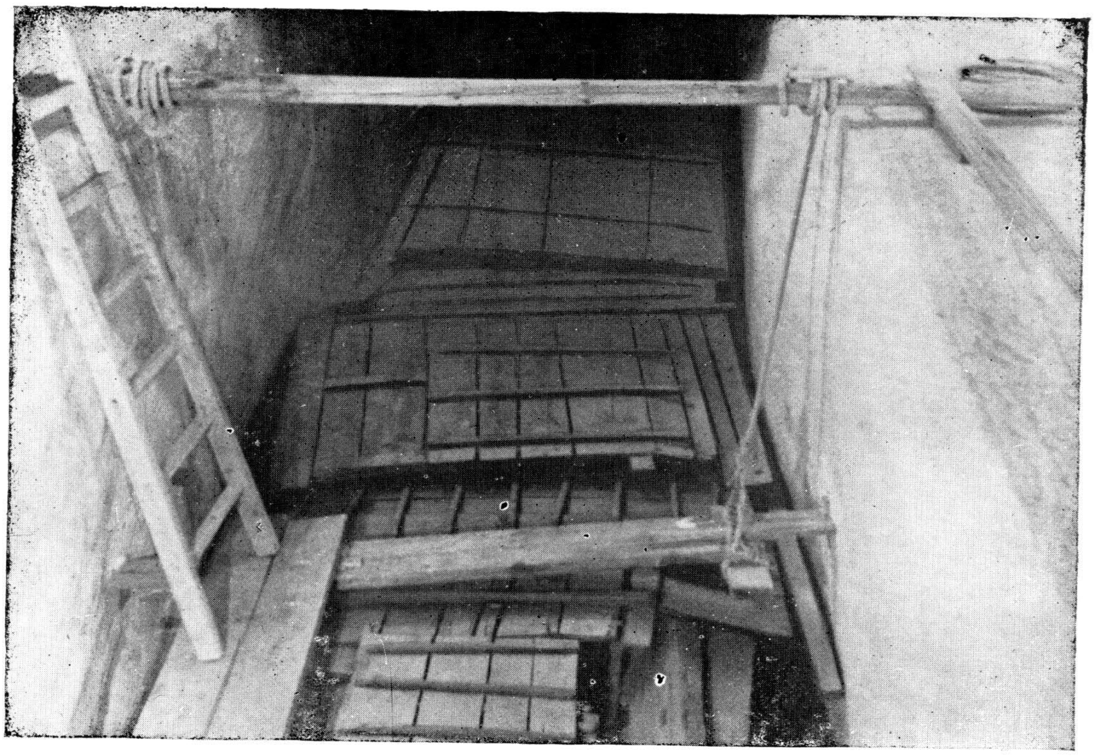


Separate parts of the boat to record their condition before lifting them.

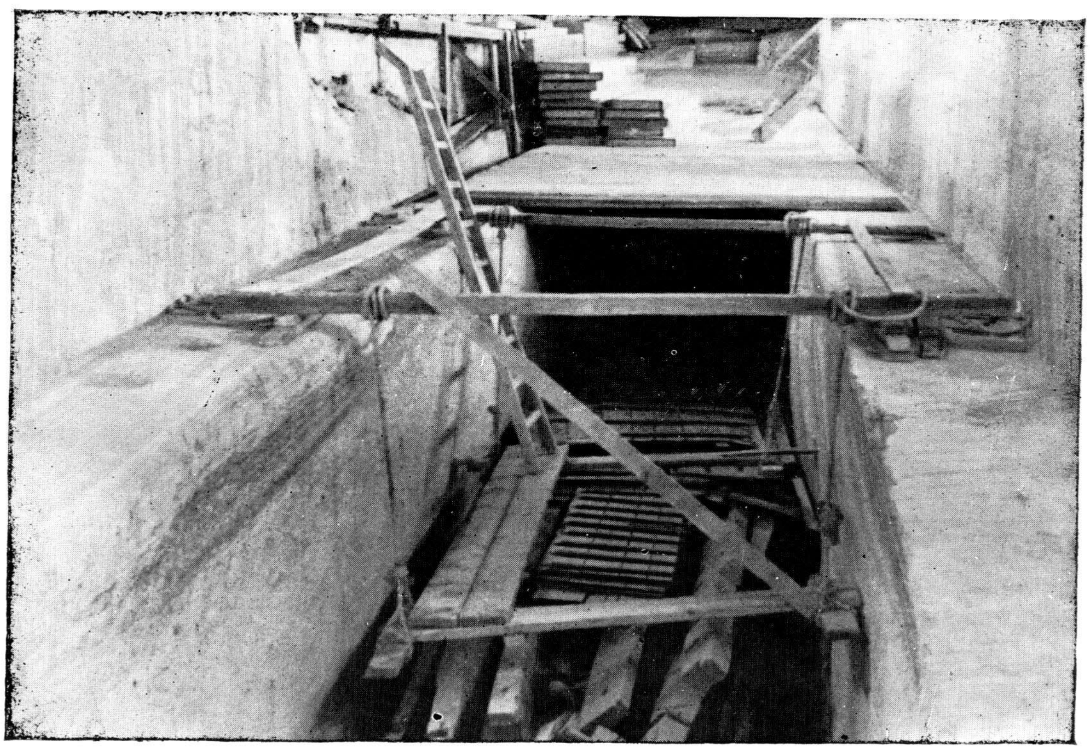


Photograph showing the position of the single pieces relative to each other.

REACHING THE SURFACE OF THE BOAT WITHOUT BEING SUPPORTED ON IT:

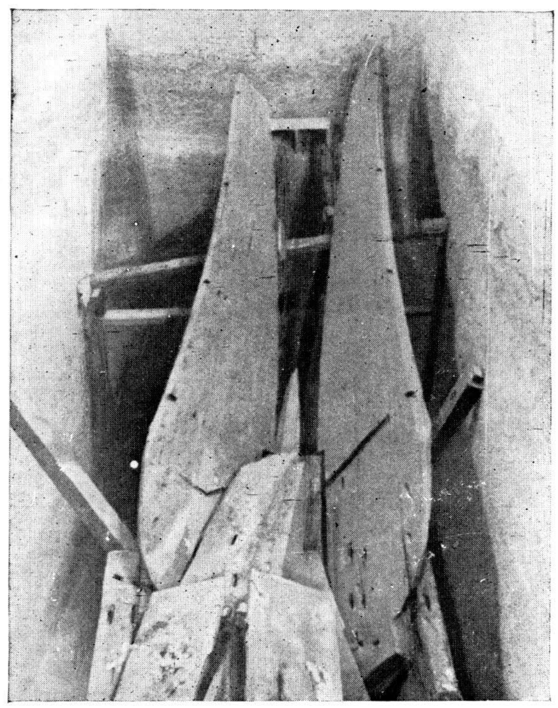


A.—A wooden scaffold hung in the pit, it is about 20 cms. higher than the surface of the parts.

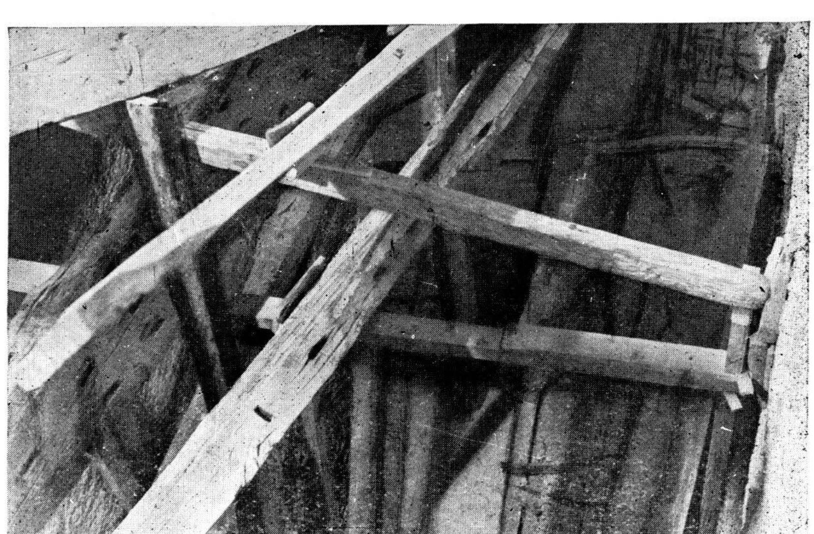


B.—The beams, boards and ropes composing the scaffold and the way they were put together.

PROTECTION OF THE PIECES BEFORE LIFTING THEM UP;

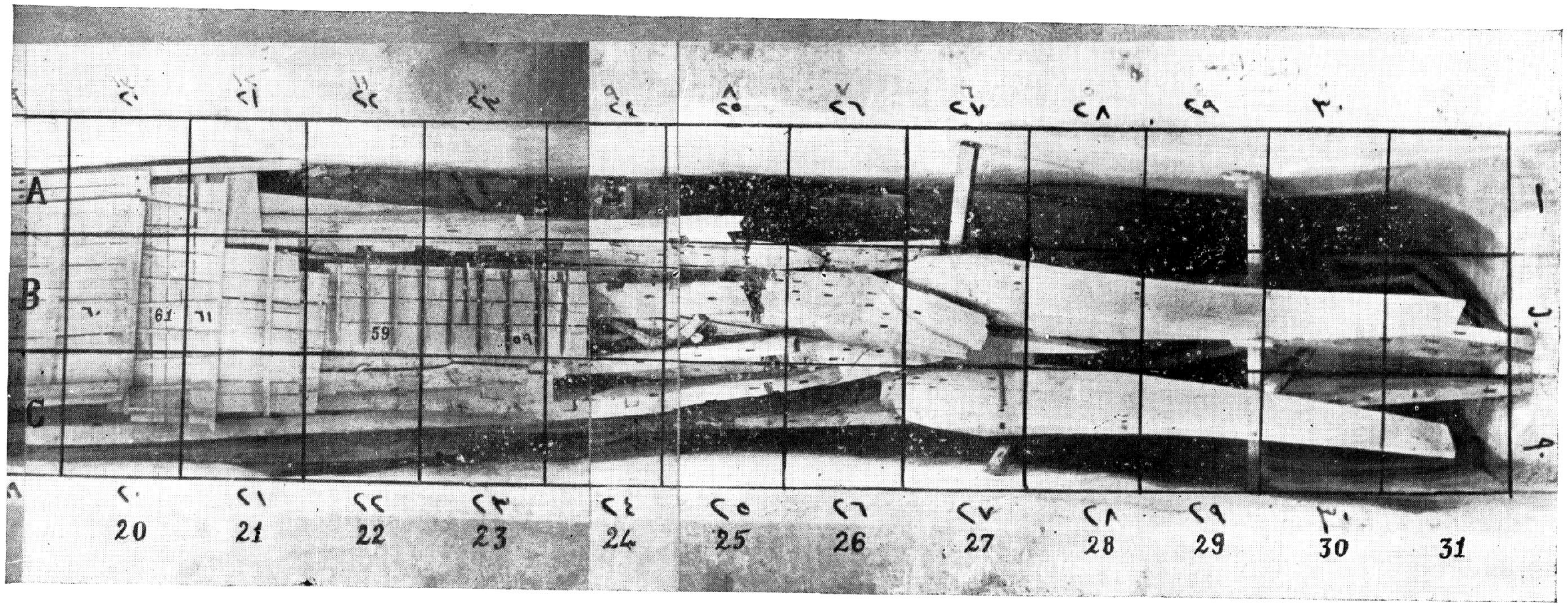


A.—Supporting the weak pieces on wooden beams to protect them.



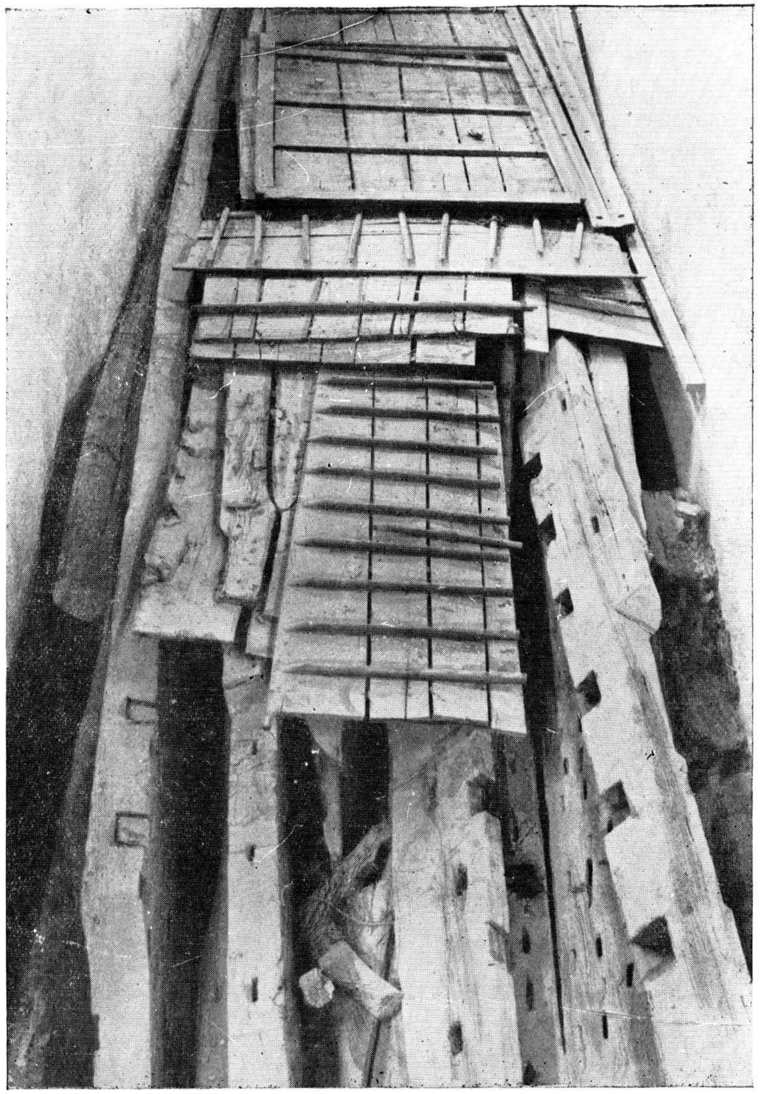
B.—The supports as seen between the layers.

Pl. LI

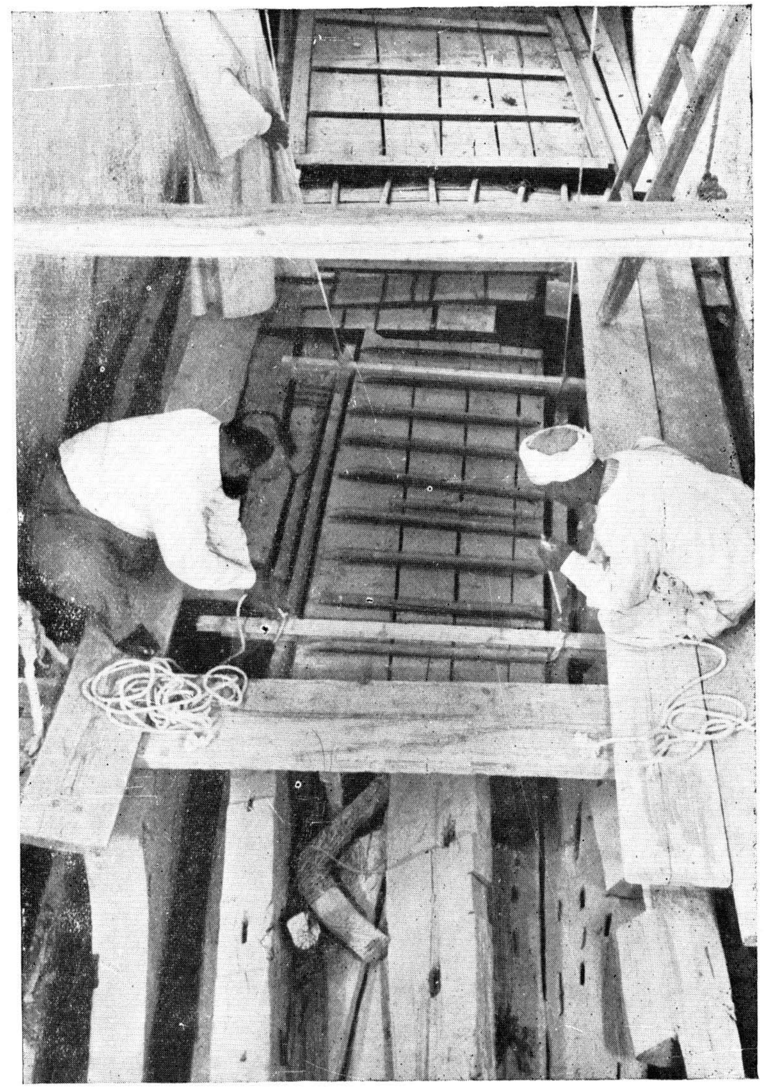


Part of the photograph of the fourth layer, divided into squares for determining the position of each piece before lifting it up.

LIFTING UP THE WOODEN PARTS OF THE BOAT, EXAMPLE I:

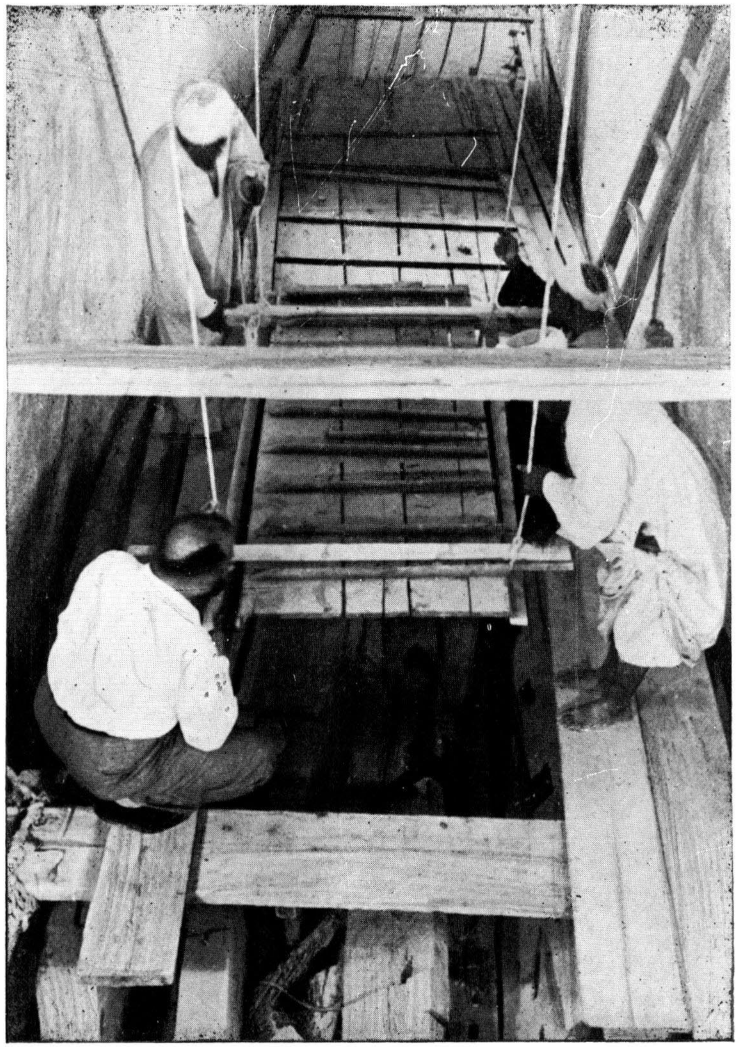


A.—A photograph of a door before lifting it, recording its condition as found in the pit.

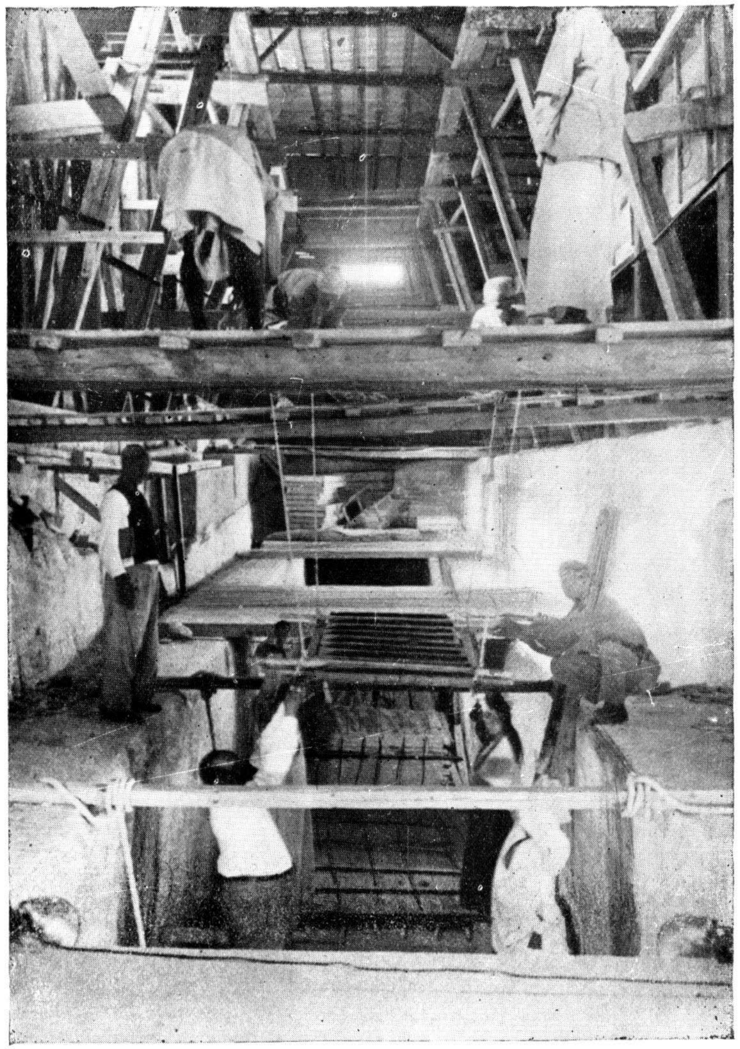


B.—Putting the scaffold, inserting the door between wooden crossbeams and tying them with ropes.

LIFTING UP THE WOODEN PARTS OF THE BOAT, EXAMPLE I (*continued*) :



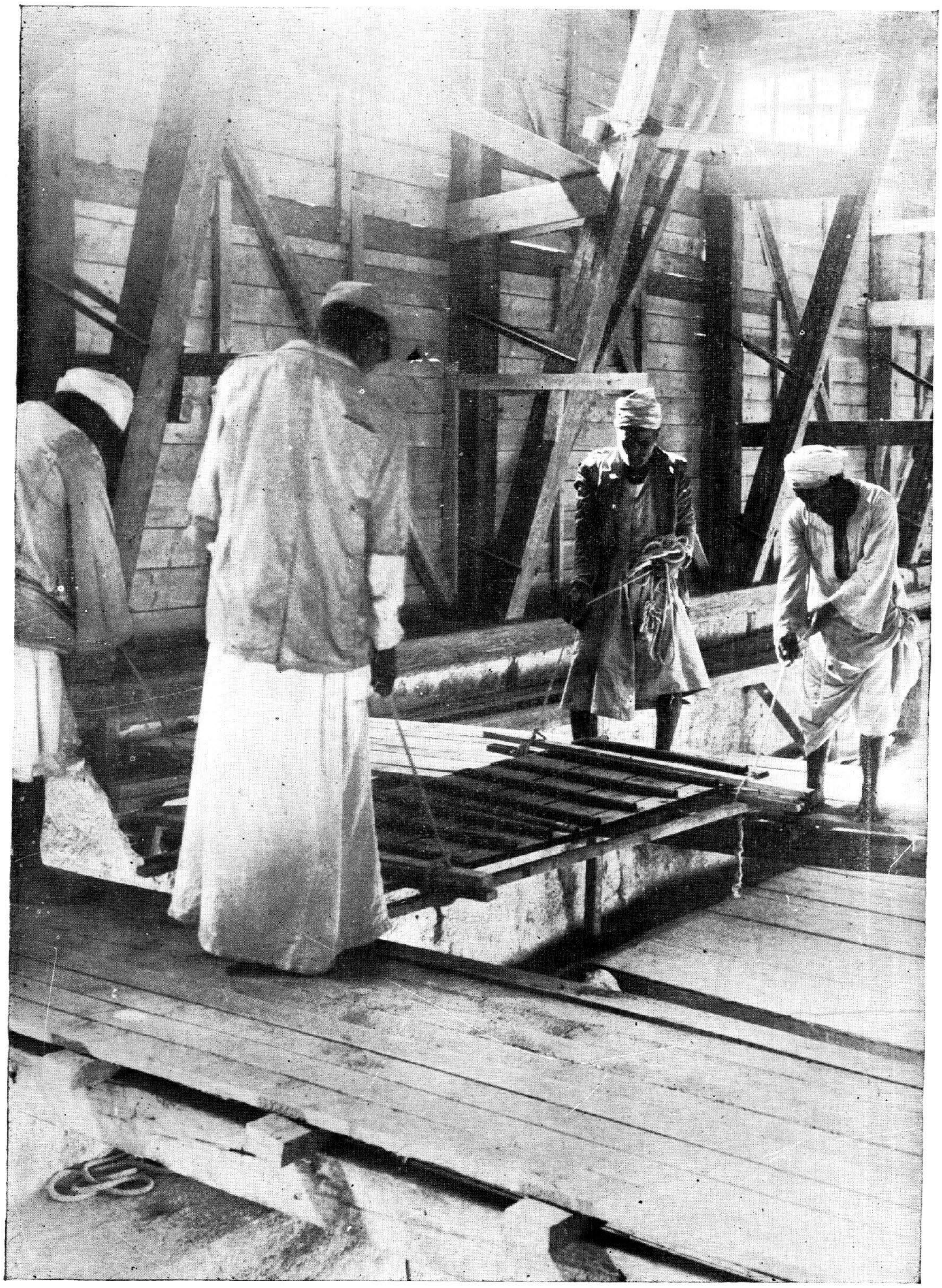
A.—Lifting the piece with ropes while keeping the boards of the scaffold in the pit as they are.



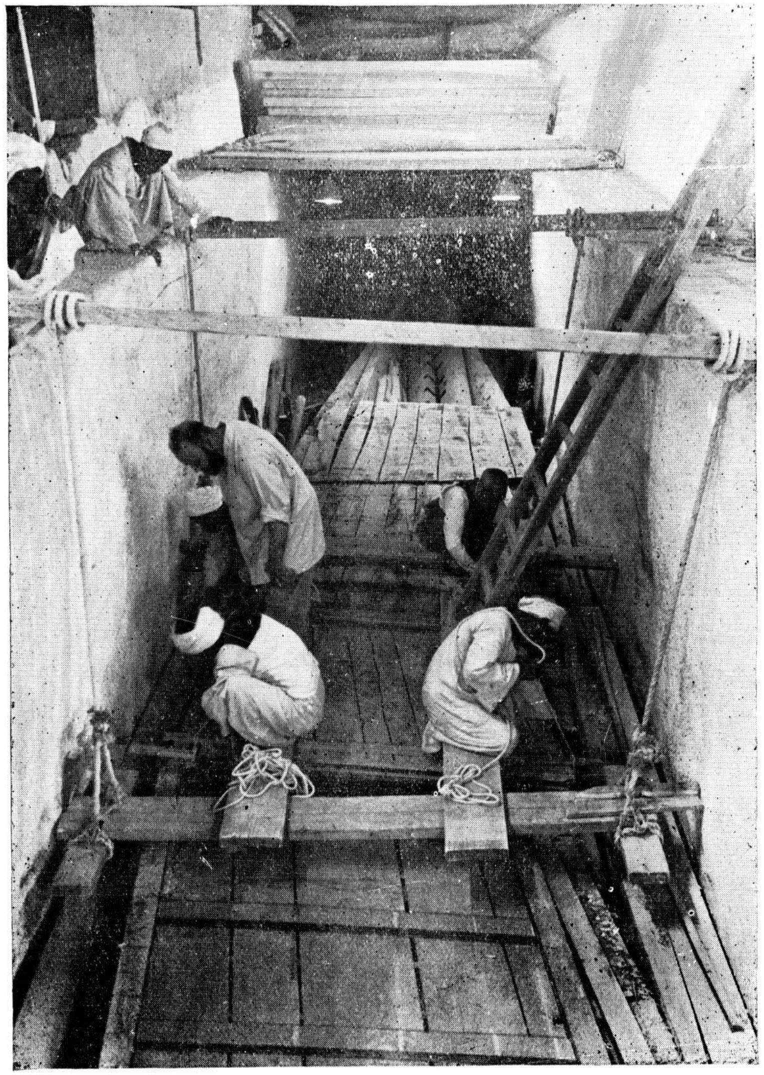
B.—Pulling the piece to the level of the pit-head.

Pl. LIII

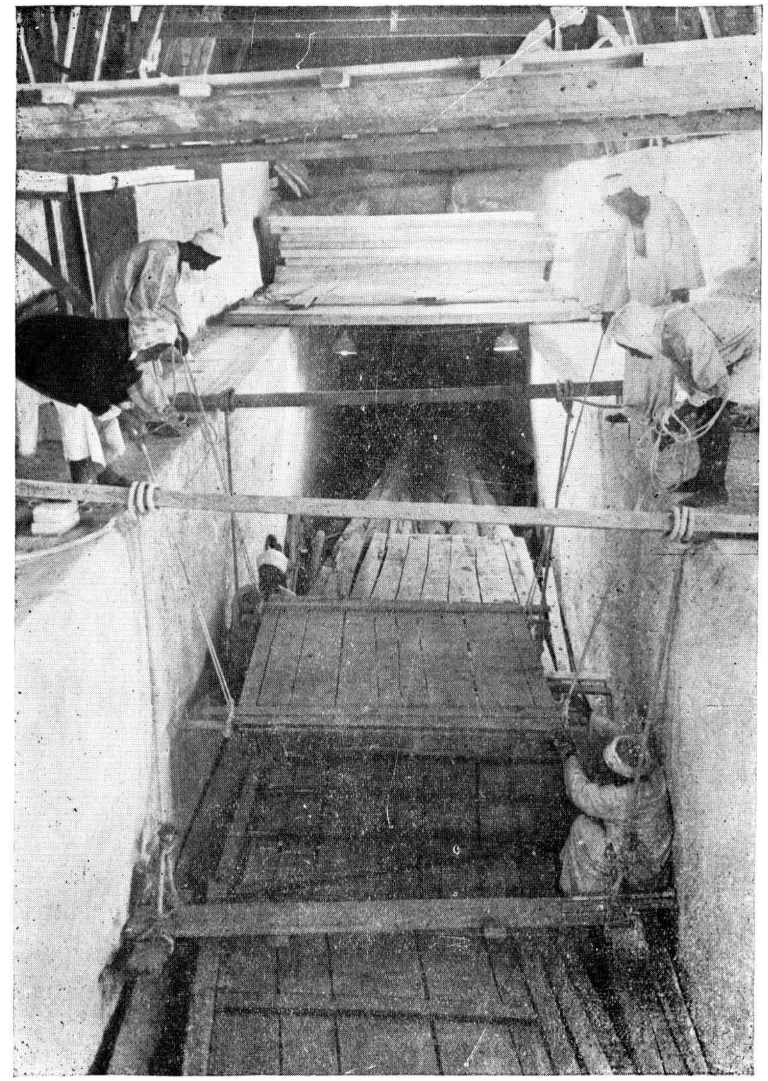
LIFTING UP THE WOODEN PARTS OF THE BOAT, EXAMPLE I (*continued*):



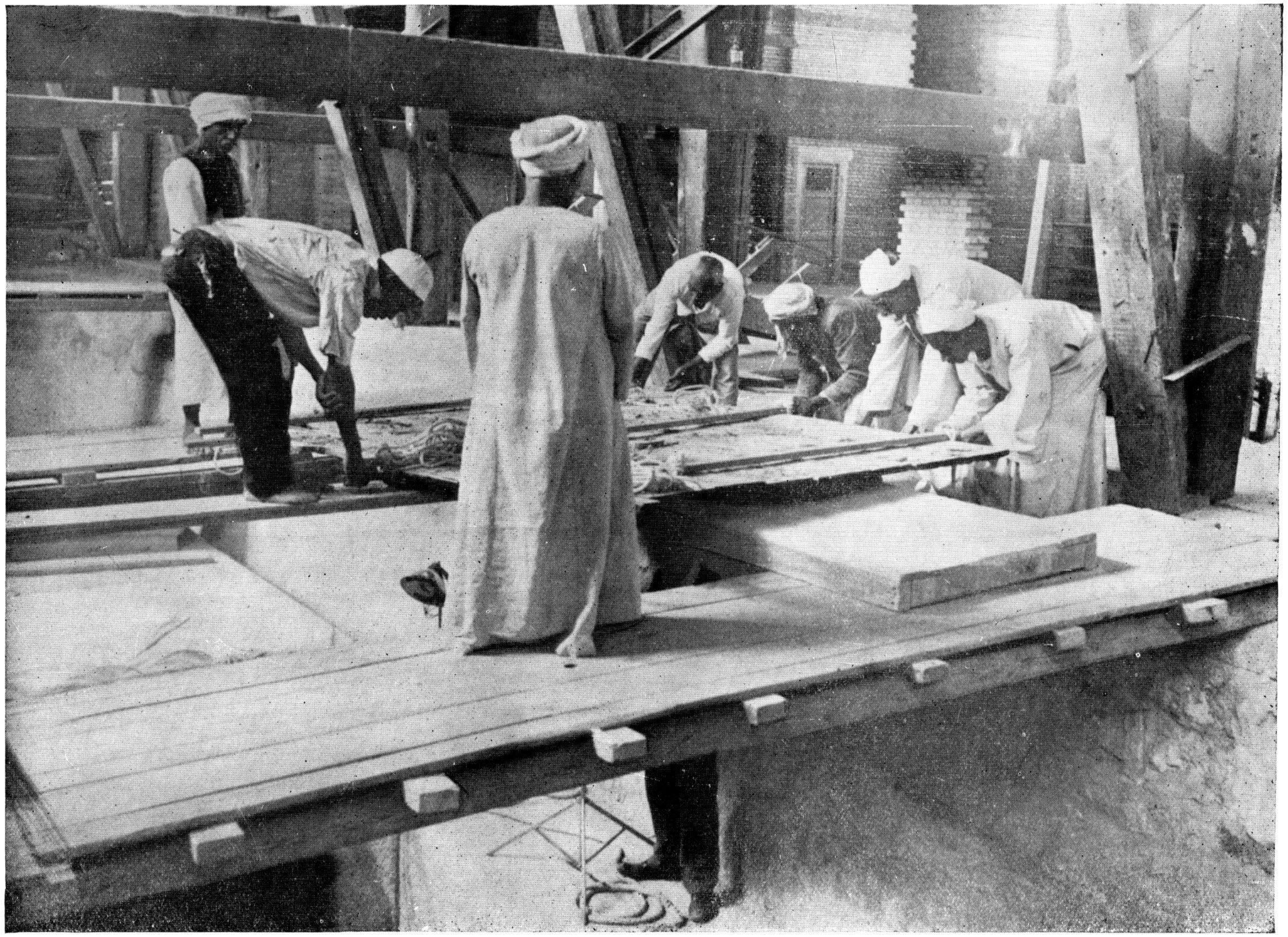
The piece reaching the level of the pit-head.



A.—Putting the longitudinal boards of the scaffold inwards and tying the cross-beams with ropes.

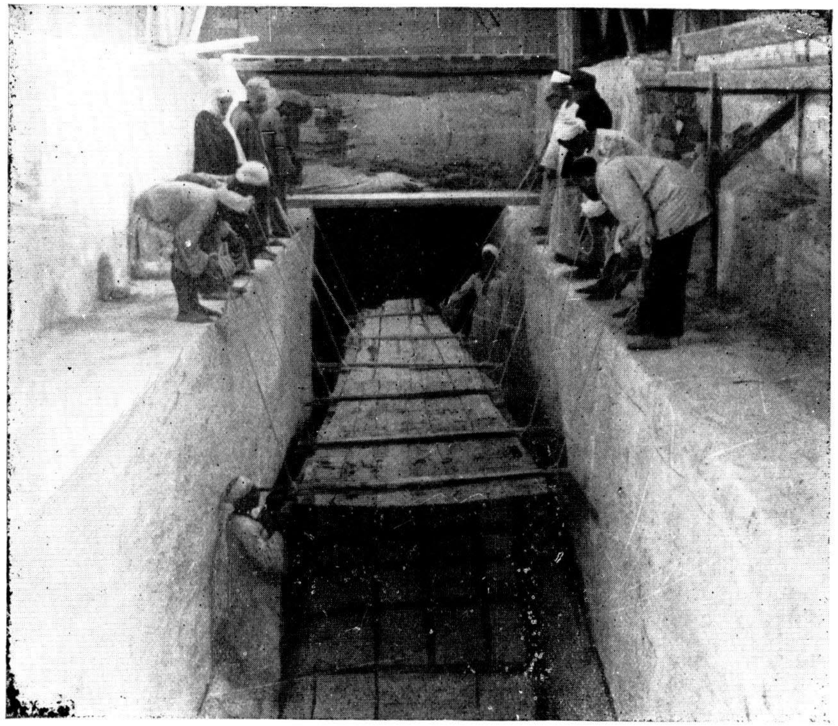


B.—Taking the boards of the scaffold away and lifting up the piece.

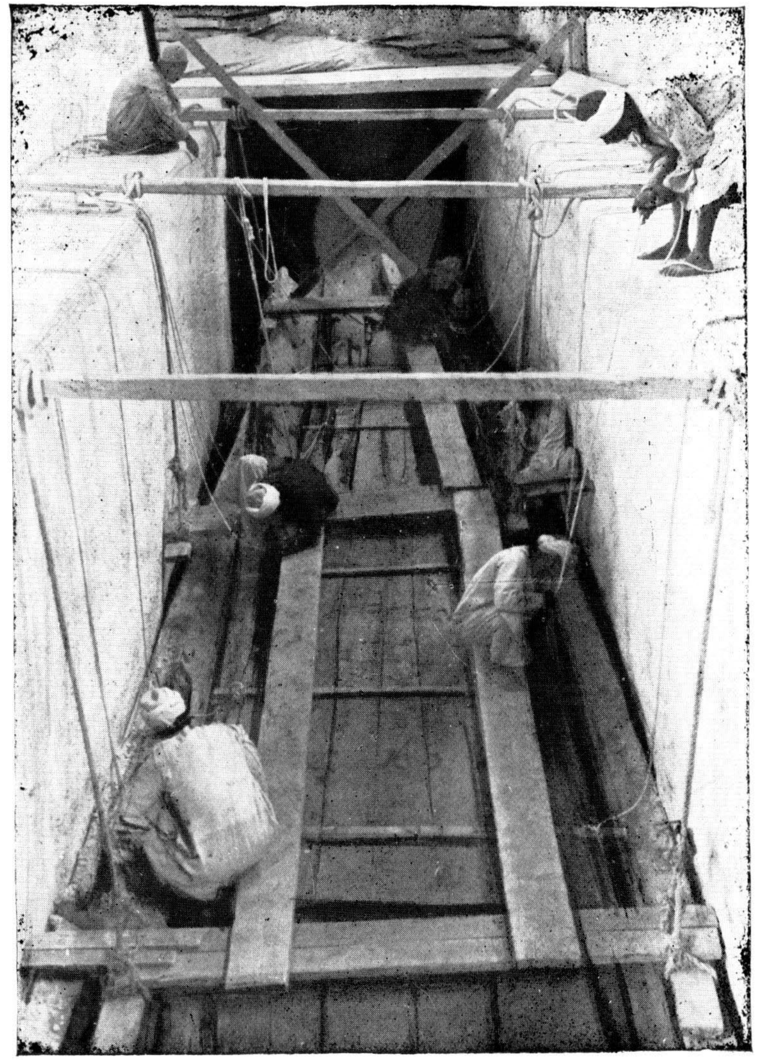


Insuring the safety of the loose pieces while carrying them to the restoration studio by supporting them over a board.

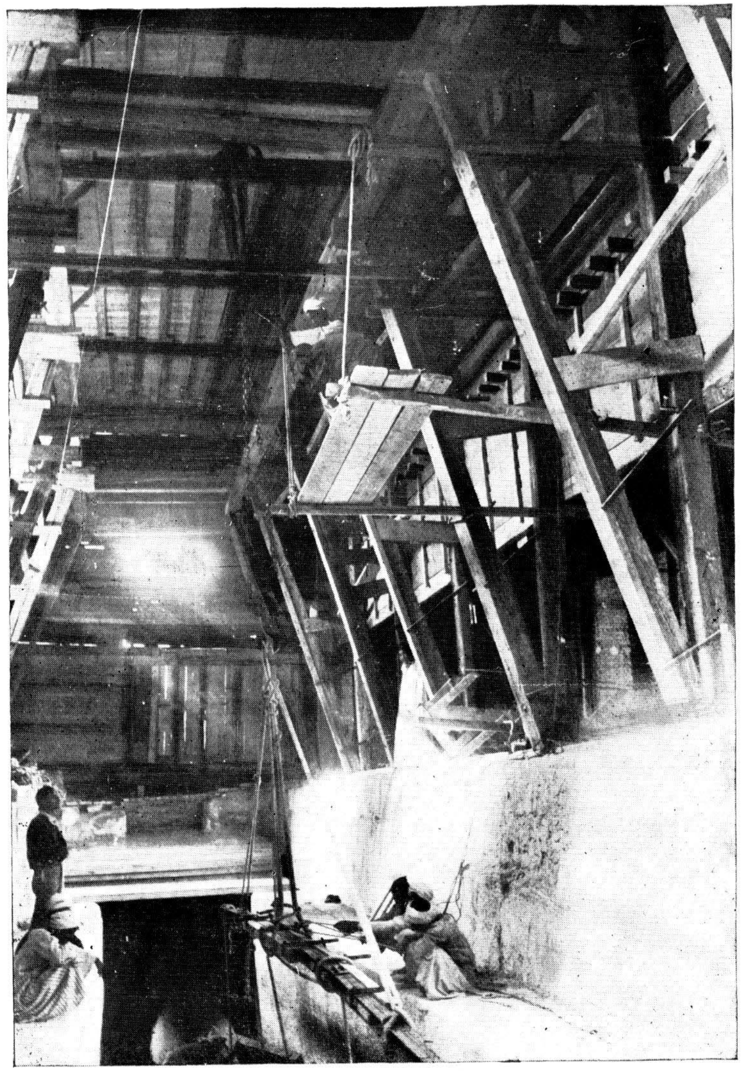
Pl. LVI



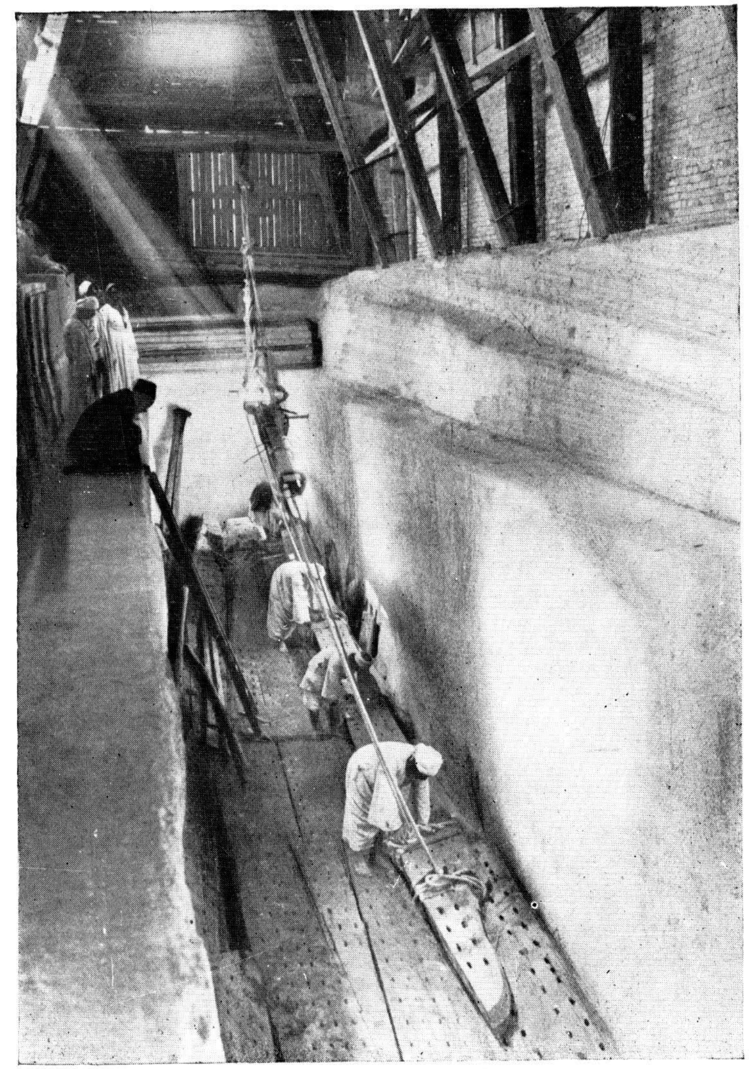
A.—Repeating the unit of the scaffold and tying the cross-beams with ropes.



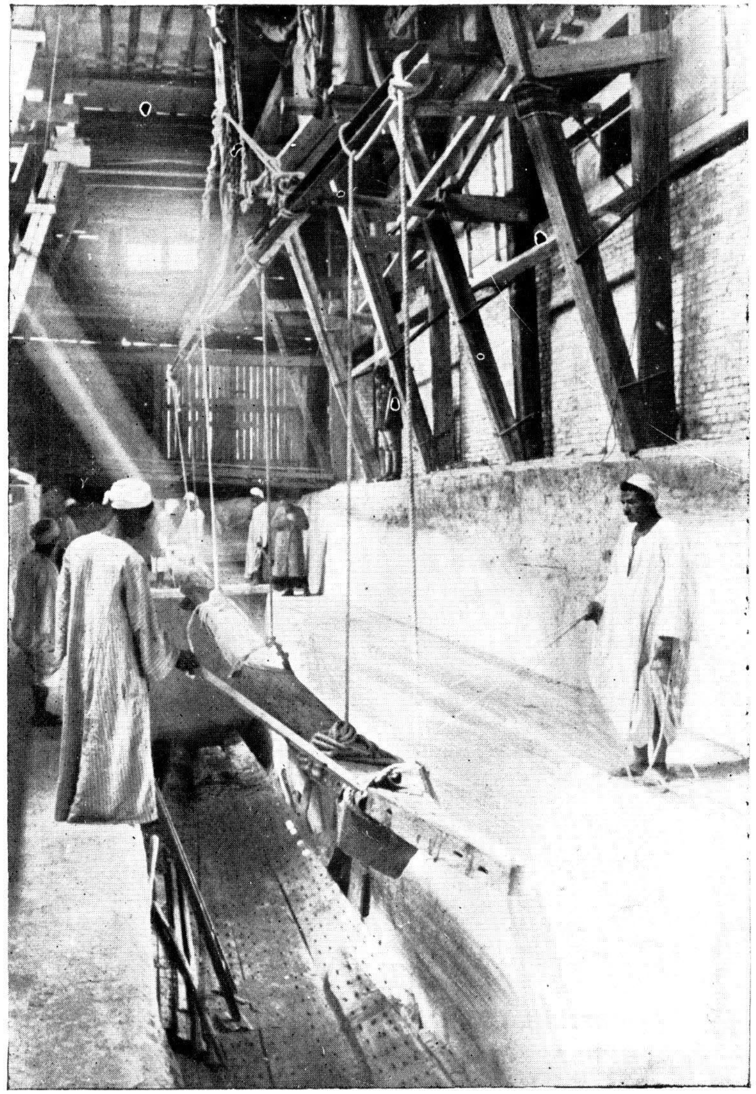
B.—Removing the skeleton of the scaffold and lifting the piece with ropes fixed at the pit-head.



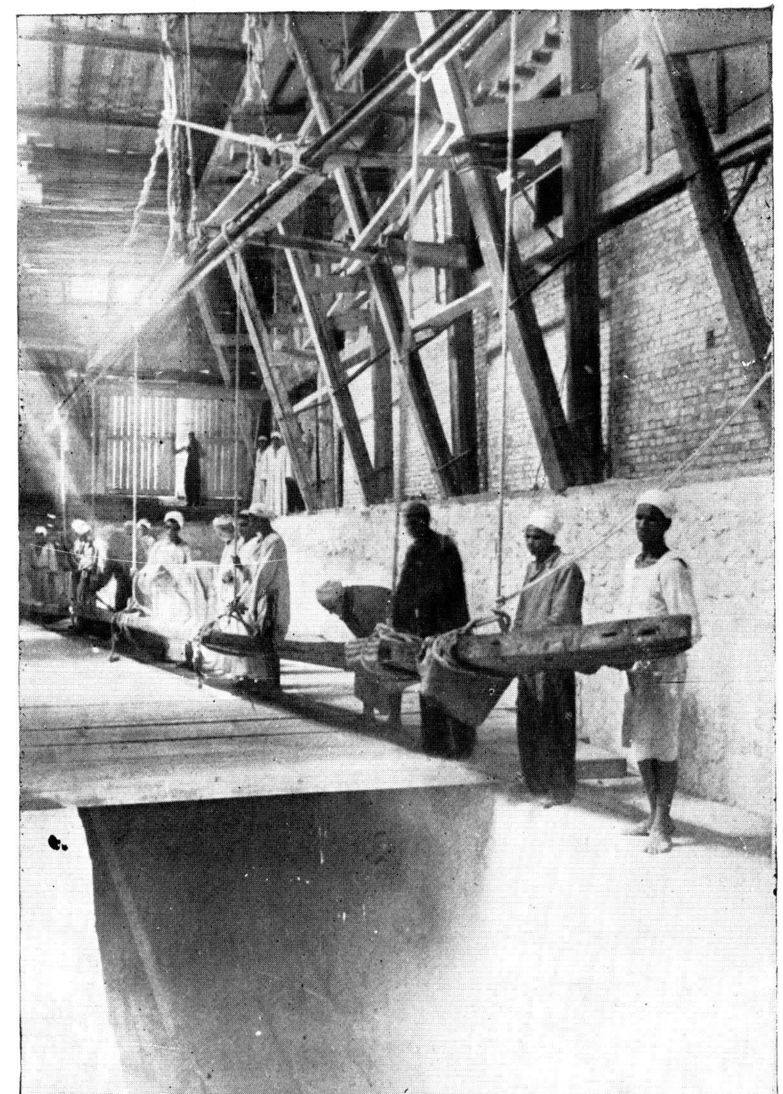
A.—The crane hung in the roof of the shelter. An iron beam tied to its hook and hanging in the pit.



B.—Tying the piece with ropes hanging down from the iron beam.

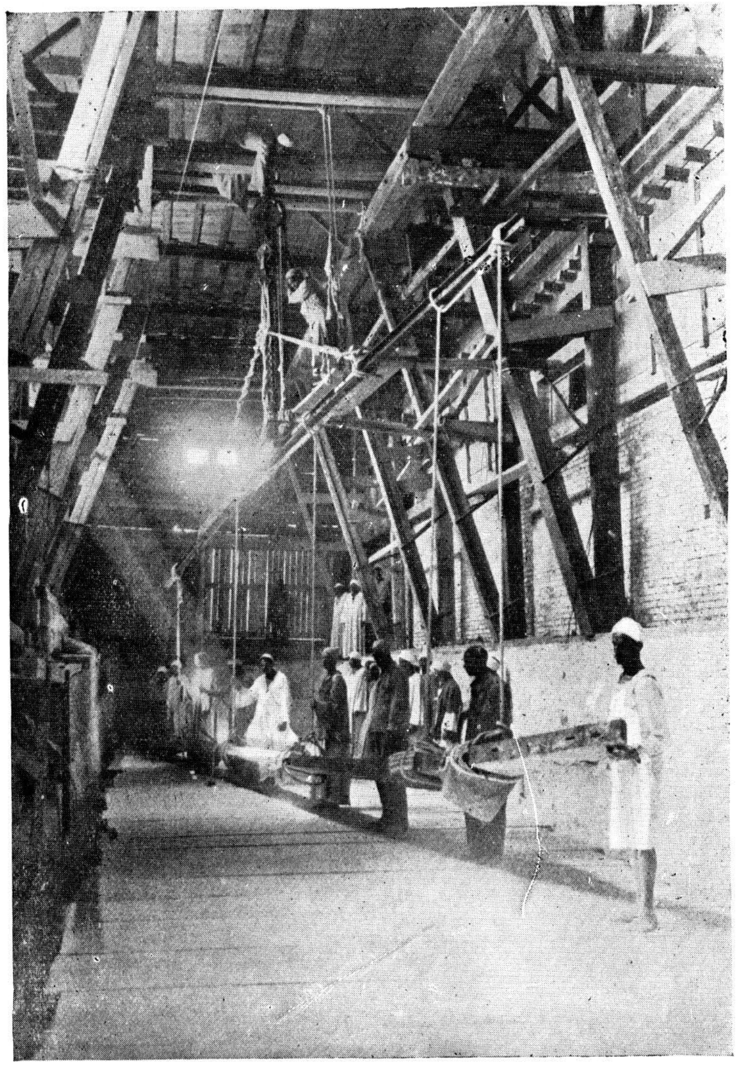


A.—Lifting up the log to the pit-head.

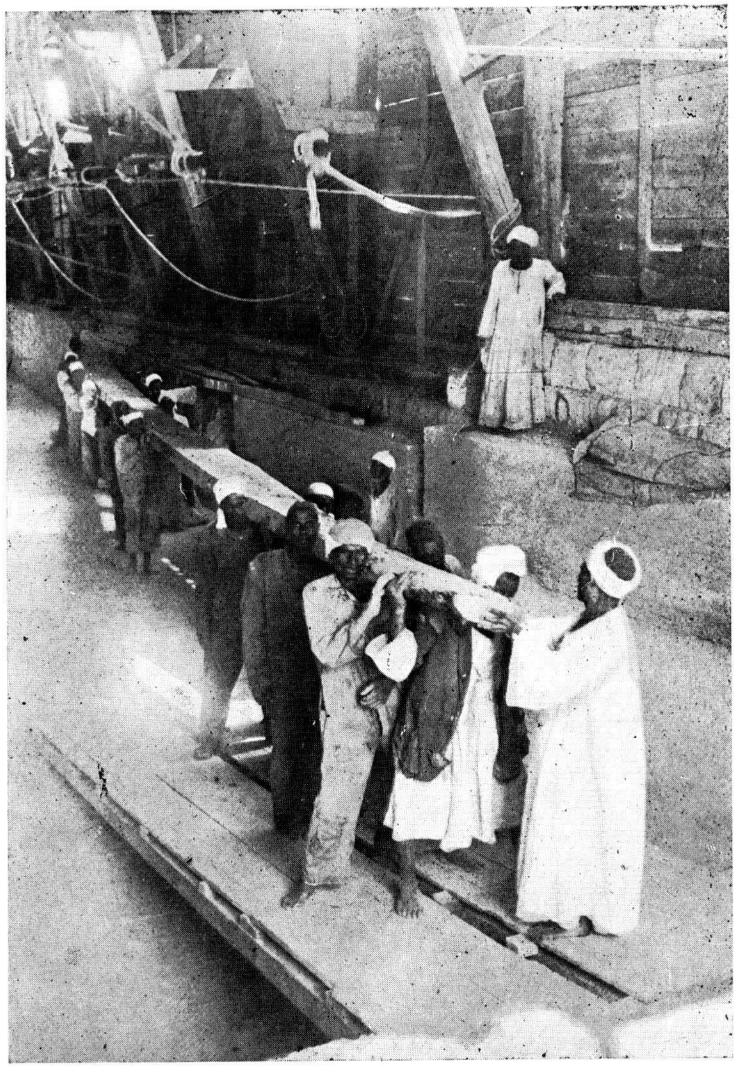


B.—Putting wooden boards (to cover the pit and serve as a ground) under the log after lifting it.

LIFTING UP THE WOODEN PARTS, EXAMPLE IV (*continued*) :



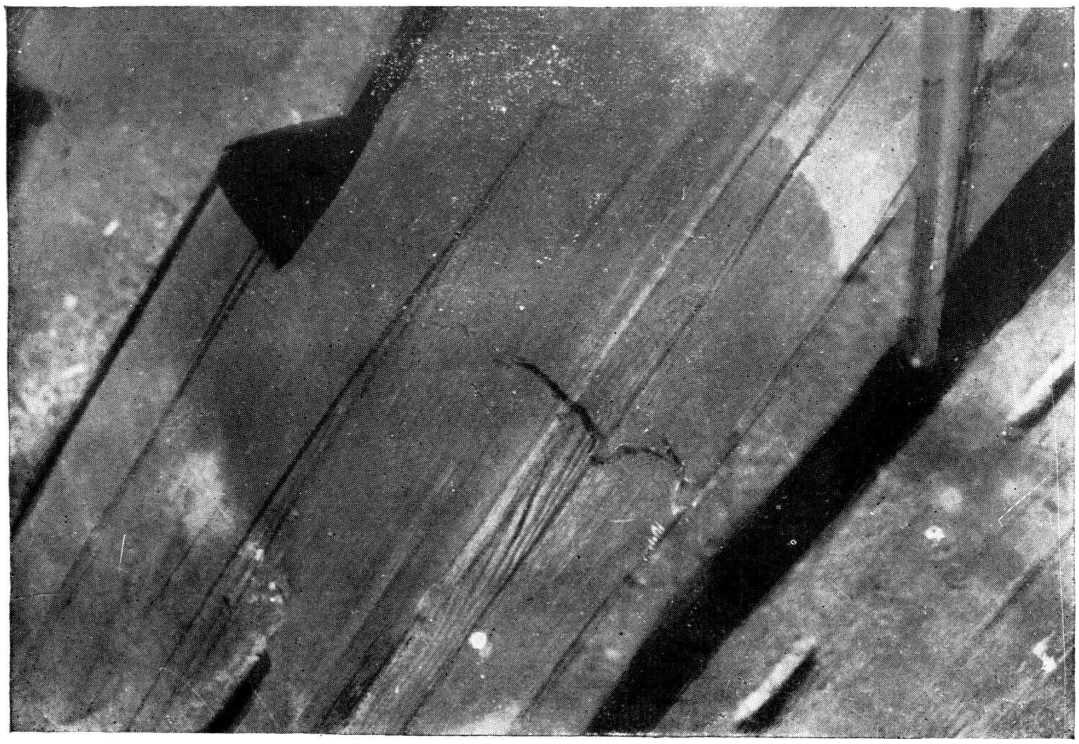
A.—The labourers standing on the wooden boards after covering the pit, ready to untie the log.



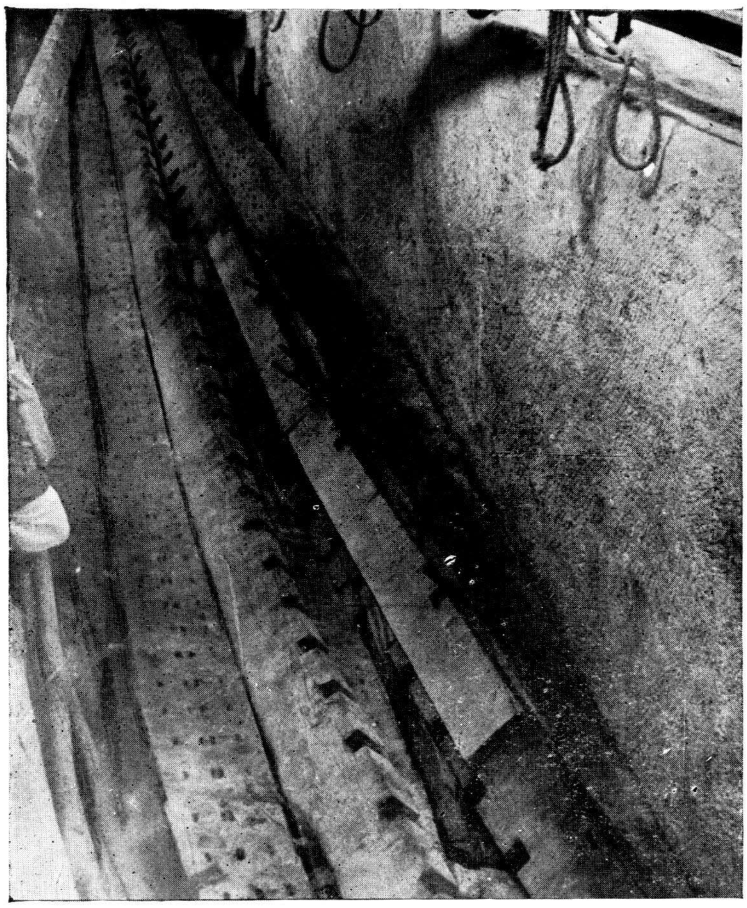
B.—Untying the log from the crane and carrying it to the restoration studio.

Pl. LX

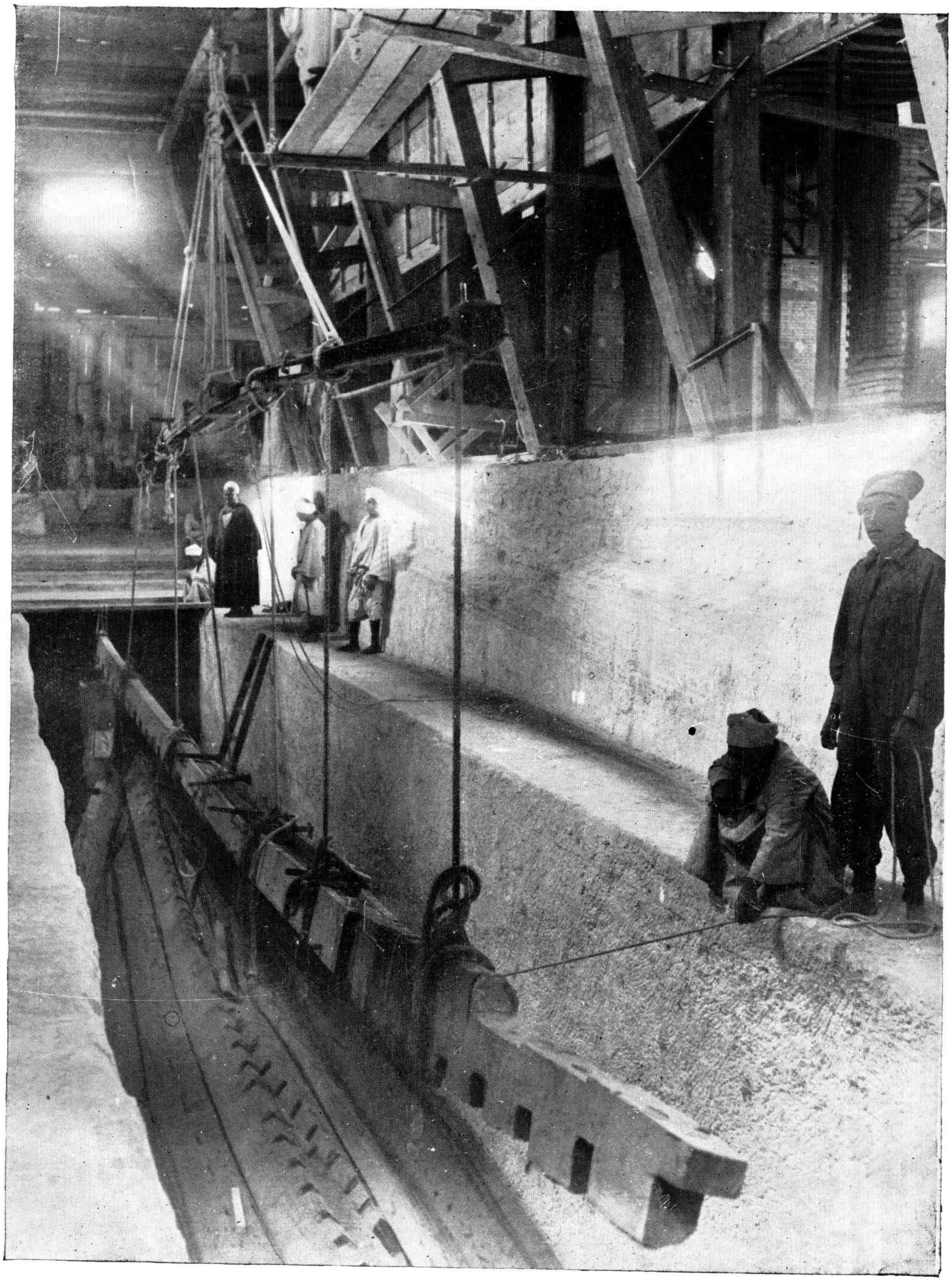
LIFTING UP THE WOODEN PARTS: EXAMPLE V:



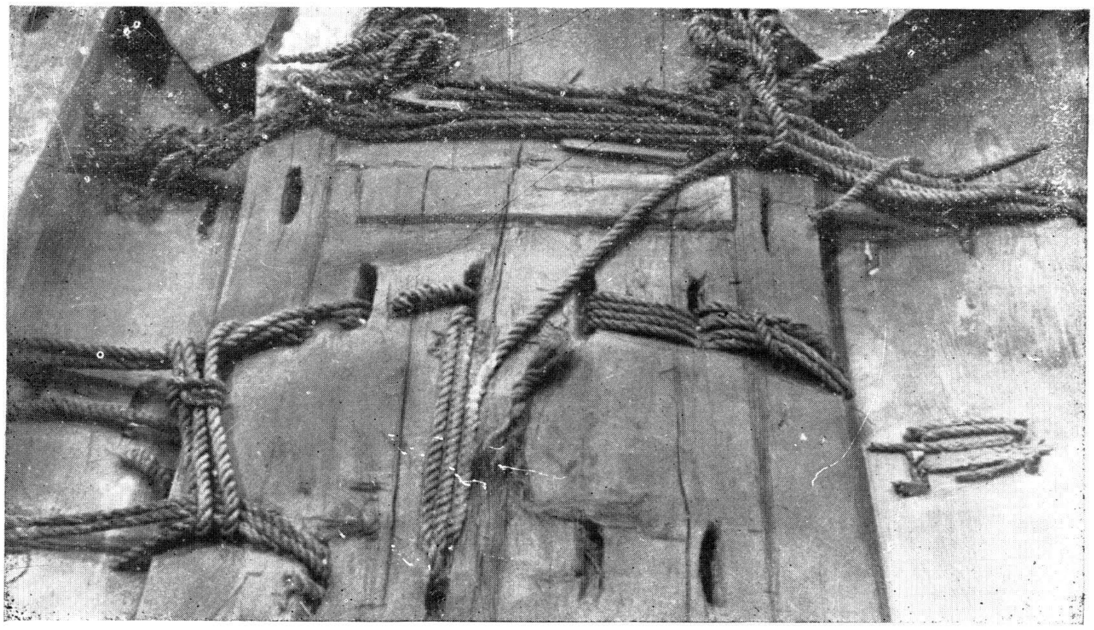
A.—One of the several cracks found in a wooden piece before lifting it.



B.—Putting wooden boards round the cracks and fixing them with clamps.



Lifting up the cracked piece with the fixed boards along the cracks. The crane, the beam and ropes can be clearly seen.

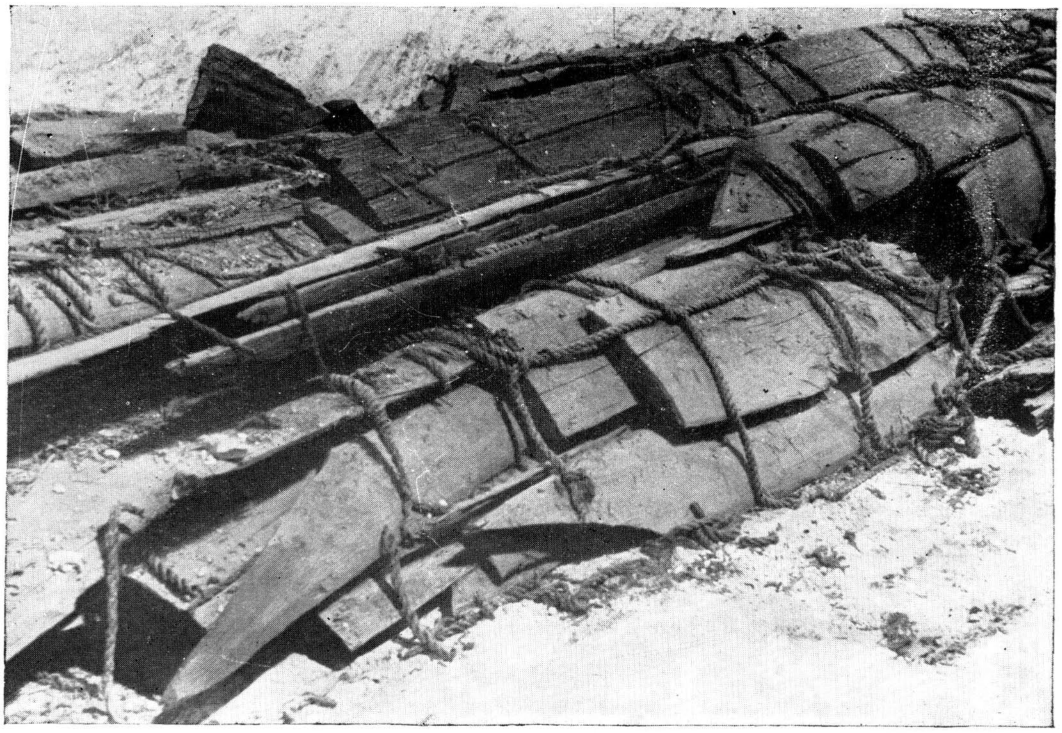


A.—An example of the ancient ropes found lashing some parts of the boat.

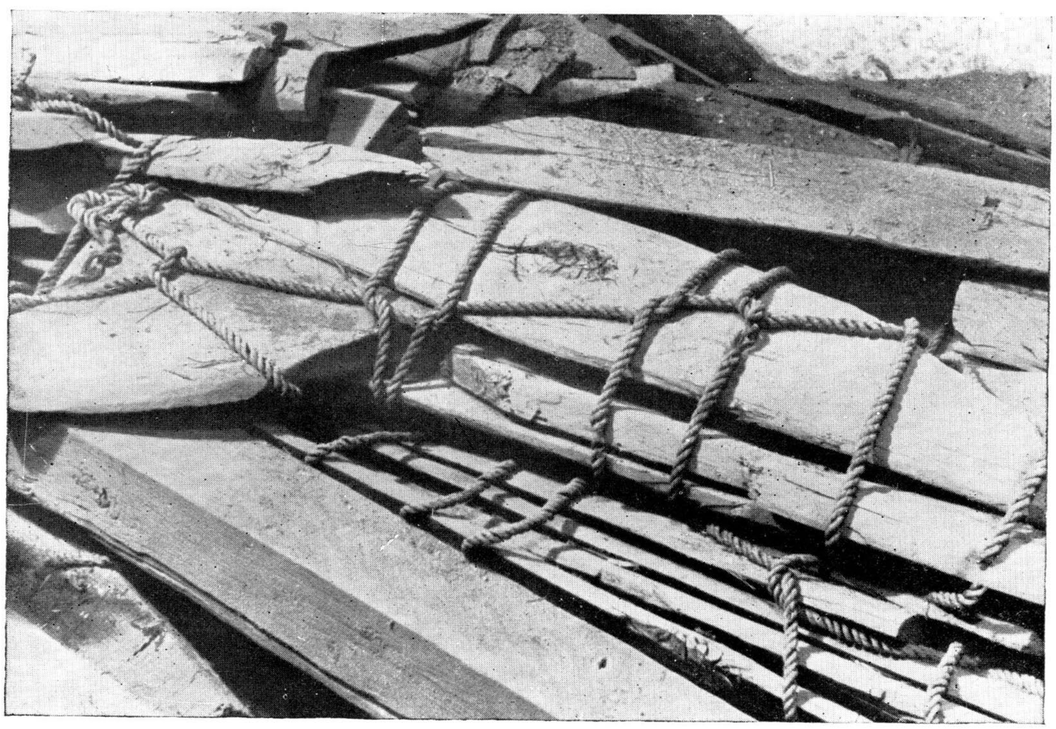
B.—A collection of the ancient ropes which were found between the layers.

A heap of the ropes which were found at the bottom of the pit under the wooden parts of the boat.

PIECES OF WOOD THAT WERE FOUND IN BUNDLES AT THE BOTTOM OF THE PIT:

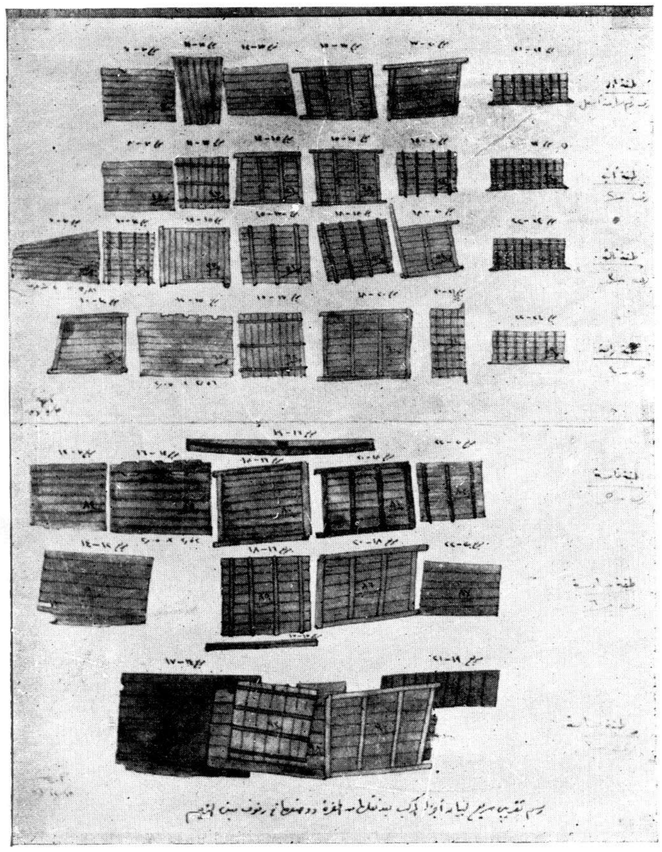


A.—Wooden pieces of different shapes tied with ropes.

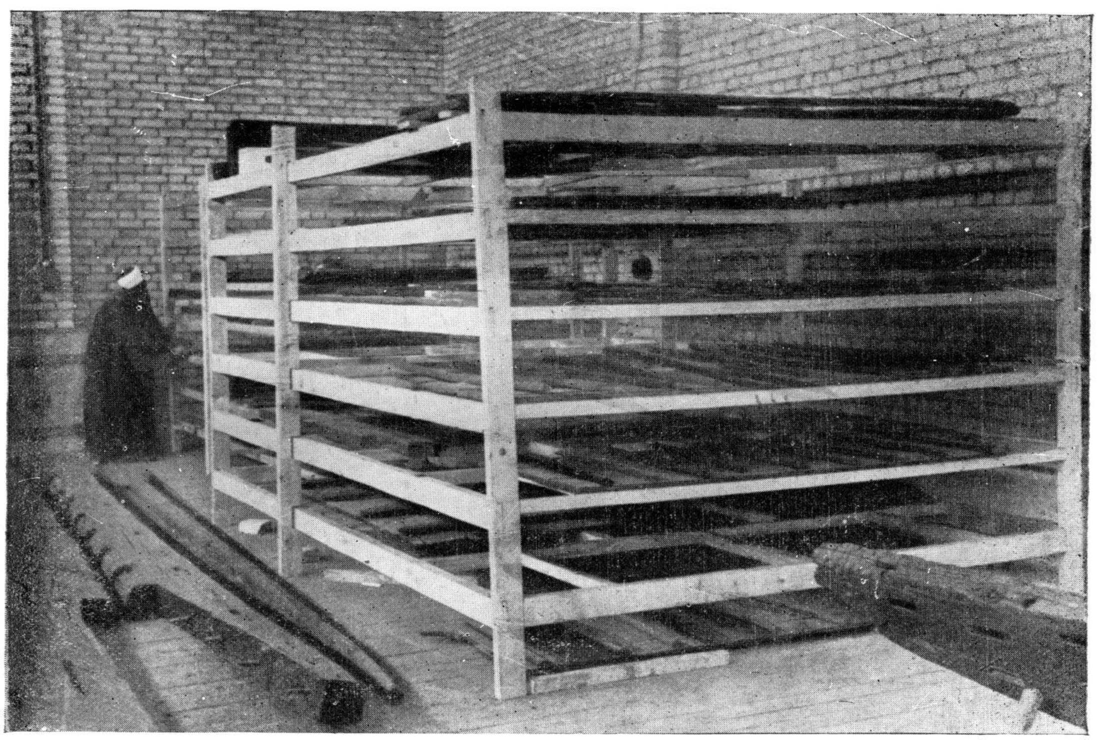


B.—One of the collections of the wooden pieces. It shows the way they were bound with ropes.

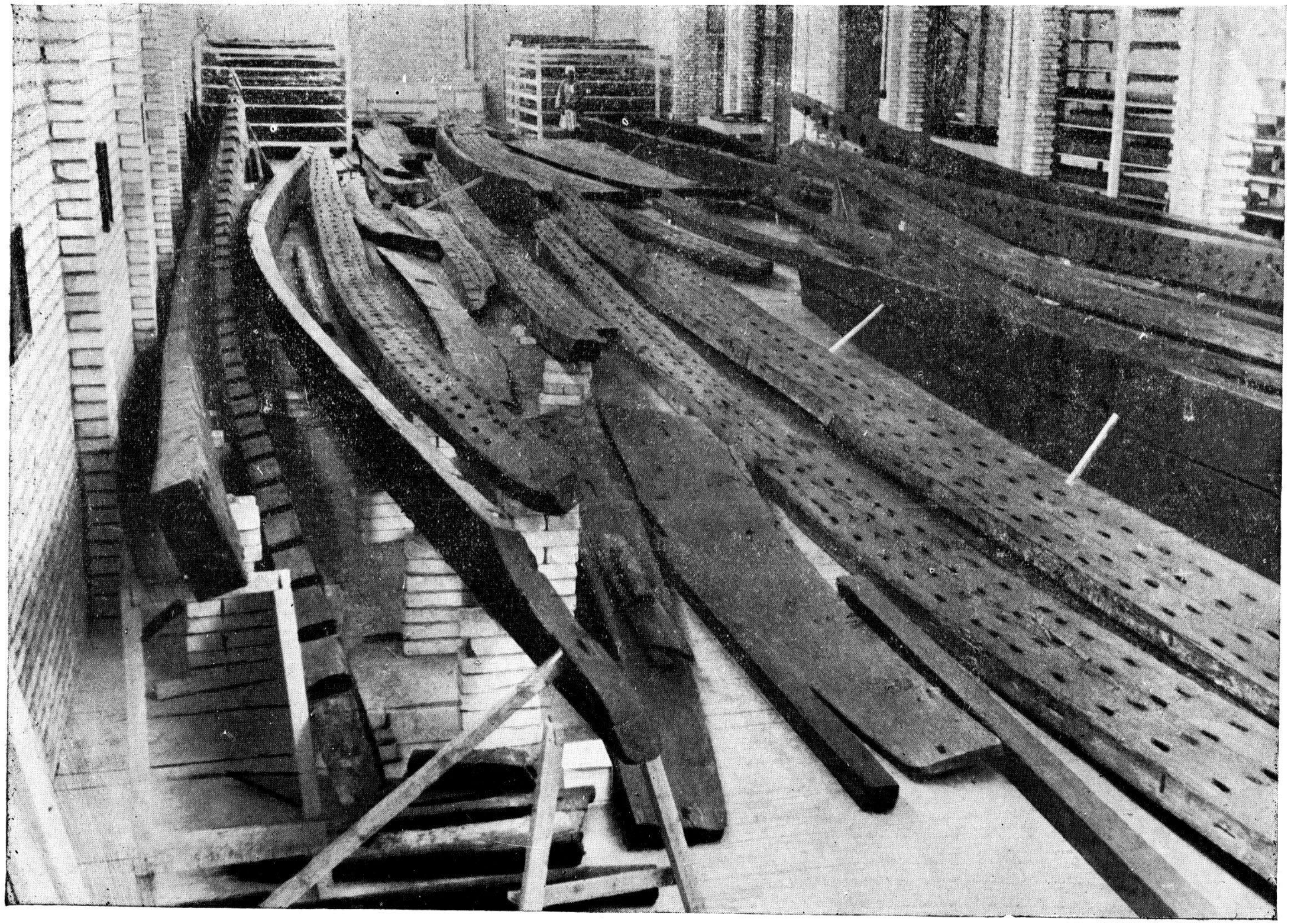
ARRANGING THE PARTS OF THE BOAT IN THE RESTORATION STUDIO :



A.—A sketch of the analogous pieces found in the consecutive layers.



B.—Arranging the ancient pieces on the wooden shelves in nearly the same order as they were found in the pit



Most of the wooden parts of the boat in the restoration studio.

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