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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
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15 January 1946

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Bombproof Construction in Japan.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target X-31 of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and preparation of the target report were accomplished by Lieut. W.F. Reardon (CEC), USNR, and Lieut. D.G. Radcliffe (CEC), USNR, assisted by Lt.(jg) J.R. Thayer, USNR, as interpreter and translator.

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32413

RESTRICTED X-31

BOMBPROOF CONSTRUCTION IN JAPAN

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-31

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MISCELLANEOUS TARGETS

BOMBPROOF CONSTRUCTION IN JAPAN

In the field of bombproof construction there are three main subdivisions, namely: construction above ground, construction in tunnels and caves, and underground structures specially constructed.

On low lying flat areas it was necessary to design and build bombproof structures wholly above ground. Although designs were made for construction against 1000 and 2000 pound bombs, construction was realized only for protection against the 500 pound bomb. The average amount of protection given was reinforced concrete construction of 1.5 meters in thickness, overlayed with earth. Structures thus built were used for personnel shelters, and for miscellaneous small shops. They were, on the whole, well designed and well executed. Most of this type of construction was very high priority work and was not too common because of the shortage and expense of materials and skilled labor. The common type of bombproof construction in Japan is the tunnel or cave, since the geological structure and the terrain lent themselves ideally to this type of construction and the minimum amount of skilled labor, material, and equipment is needed. Japan abounds in examples of tunnel construction. On the whole they served the purpose for which they were intended but, from a construction viewpoint, few could be called good. Most of the tunnels were damp, the only drainage being accomplished by ditches on the tunnel sides. Ventilation always was poor and artificial ventilation seldom was used. Lighting was barely sufficient; heat and toilet facilities were nonexistent. The majority of tunnels were unlined and unshored due to the excellent shale material in which they were dug. Tunnels were lined only when the span became too great and these tunnels of concrete arch design were well constructed. One of the most outstanding examples of this latter type of tunnel exists at YOKOSUKA airfield, where a concrete arched tunnel of 20 meter span was constructed without shoring.

Specially constructed bombproof structures below ground were extemely rare, owing to shortages of materials and skilled labor. One excellent example was investigated, the Underground Headquarters of the Japanese Navy Ministry. Here was a structure designed against the direct hit of a 5000 pound bomb and although it received no direct hits, it survived the bombing raids on TOKYO. Constructed in 1941-42, it shows evidence of much thought and planning. It contained adequate heating, ventilating, lighting, and drainage facilities. This structure would compare favorably with any similar design in the United States and is of great interest to American engineers.

Apparently the Japanese realized too late the importance of bombproofing and dispersal. The scarcity of materials and skilled labor accounted for much of the poor and unfinished construction. When they did design and plan and were able to carry through, the results usually were good.

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REFERENCES

Location of Target:

1. Kisarazu Airfield, KISARAZU.
2. Hitachi Aircraft Co. Dispersal Plant at OAMI.
3. Yokosuka Airfield, YOKOSUKA.
4. Tateyama Air Base, TATEYAMA.
5. Kure Naval Base, KURE.
6. Underground Headquarters of the Japanese Navy Ministry, TOKYO.

Japanese Personnel Interviewed and who Assisted in Collecting Documents:

1. Mr. Shigeru MORI, former Lt. Comdr. and third ranking officer in the General Affairs Department of the Civil Engineering Headquarters of the Imperial Japanese Navy. A graduate of the Civil Engineering School of Tokyo Imperial University.
2. Mr. Tashiro SHIRAISHI, President of the Shiraishi Foundation Company, TOKYO.
3. Mr. M. SATO, Assistant Chief Engineer of the Shiraishi Foundation Company, TOKYO.
4. Mr. Masao YAMAMOTO, Former Lieutenant and Commanding Officer of the 300th Construction Battalion of the Imperial Japanese Navy.
5. Mr. Fumio IITSUKA, Former Lieutenant and Commanding Officer of the 3015th Construction Battalion of the Imperial Japanese Navy.
6. Mr. Keiichi TSUDA, Former Lieutenant attached to the Civil Engineering Headquarters of the Imperial Japanese Navy.

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(C) Personnel Shelter at KISARAZU airfield.

(D) Torpedo Hangar at KISARAZU airfield.

(E) Torpedo Shed at KISARAZU airfield.

(F) Pumping Station at Japanese Navy Ministry, TOKYO.

(G) Chart of Detailed Study of Air Defense Walls for Pump Houses at Building Dock and Dry Dock No. 4.

(H) Hitachi Aircraft Company at OAMI.

(I) Underground Installations for Aircraft Manufacturing Companies.

(J) Typical Tunnel Section - Hitachi Aircraft Company at OAMI.

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(M) Underground Headquarters of the Japanese Navy Ministry, General Drawing.

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INTRODUCTION

In investigating the problem of bombproof construction in Japan it was necessary to ascertain what had been accomplished by other technical intelligence agencies. After this, key Japanese personnel were interviewed and the extent of bombproofing was determined.

Since it would have been impossible to investigate all examples of bombproof construction, it was decided to deal with a representative cross section, and to include any outstanding examples.

In this report examples of structures for use as personnel shelters, factories, fuel depots, aircraft revetments, and utilities are described.

THE REPORT

A. Organization of the Civil Engineering Headquarters of the Japanese Navy Ministry

The organization of the Japanese Navy Civil Engineering Headquarters was headed by Vice Admiral NABESHIMA. The Headquarters was composed of four principal departments, namely: Administration, Department No. 1. Technical Dept., Department No. 2. Experimental and Research Department; and the Supply Department.

The Administration Department under the direction of Vice Admiral YAMAGUCHI was divided into two sections. Section 1, headed by Capt. KIJIMA, was known as the General Control Section and served to coordinate the activities of the other departments, determine priorities and handle personnel records. Section 2, under Comdr. SUNAMI, had cognizance over all fiscal and accounting matters, including payrolls and construction costs.

Department No. 1, Technical Dept., was under the direction of Rear Admiral GONDO, and was divided into three sections as follows: Section 3, Civil Engineering; Section 4, Architectural Engineering; Section 5, Mechanical and Electrical Engineering. The Technical Department was responsible for the preparation of designs, plans and specifications, construction methods and technical advice on engineering matters. It was in this department that the design of bombproof construction originated.

Department No. 2, Experimental and Research Dept., was under the direction of a civilian, Senior Technician Dr. FUJII. This department was divided into three sections, as follows; Section 6, Research in Civil Engineering; Section 7, Research in Architectural Engineering; Section 8, Research in Mechanical and Electrical Engineering.

The fourth principal department of the Civil Engineering Headquarters was that of Supply, the function of which was to make available to the various districts construction equipment and materials.

As the various Naval Districts received direction from the Naval Ministry on military matters, so did the districts receive direction on engineering and construction matters from the Civil Engineering Headquarters. Naval Districts with Civil Engineering Departments were located at YOKOSUKA, KURE, SASEBO, and MAIZURU. Within the districts, the Civil Engineering Departments were composed of the following sections: Administration; Accounts; Section 1, Civil Engieering; Section 2, Architectural, Electrical and Mechanical Engineering; Section 3, Supply; and the Medical Section. In addition to these district offices the Civil Engineering Departments, under the Naval Districts, had construction battalions in the field which were organized along lines similar to those of the U.S. Navy. Much of the bombardment protection was constructed by these battalions.

B. Design and Studies of Bombproof Construction

Design of bombproof construction for naval installations in Japan was under the cognizance of Section 3, Department No. 1 of the Civil Engineering Headquarters as indicated above. For structures wholly above ground designs were made against a direct hit of a 500 pound, 1000 pound, and 2000 pound bomb. However, no construction was ever realized from designs against the 1000 and 2000 pound bombs.

For designs against a 500 pound bomb the reinforced concrete roof slab was detailed as follows: Slab thickness 1.5 meters with two way reinforcing top and bottom. In the top of the slab (explosion layer) 25mm round bars were spaced at 25cm. The bottom layer of reinforcing steel was made up of from 16mm to 20mm round bars spaced at from 10cm to 15cm. In addition, a layer of wire mesh was used to prevent spalling of the underside of the slab. The top and bottom layers were tied together by stirrups which were hooked around and also welded to the top and bottom layers. The welding, however, was found to be unnecessary and was discontinued. For splicing reinforcing steel, a lap of 30 diameters was used and the ends of the bars hooked as an additional factor of safety.

The design against the 1000 pound bomb employed a bottom slab of reinforced concrete similar to that used in the 500 pound design. This slab was then overlaid with a sand cushion two meters in thickness. Over this sand another layer of reinforced concrete one meter thick was placed. For design against the 2000 pound bomb, the design against the 1000 pound bomb was expanded to include another layer of sand one meter thick, over which was placed another layer of reinforced concrete one meter thick. Thus this design called for three layers of concrete separated by two layers of sand and making a total thickness of 6.5 meters.

As an example of underground structures specially constructed, the design of the Underground Headquarters of the Navy Ministry in TOKYO is of great interest, since this building is probably the most elaborate and best designed such structure in Japan.

Experiment and research into bombproof construction came under the cognizance of Section 6, Department No. 2 of the Civil Engineering Headquarters. In addition, studies were carried on by individuals. Some of the recent studies dealing with vibrations of structures and the resistance to concussion of various types of construction are among the Japanese documents which have been forwarded to the United States (see Enclosure A).

C. Bombproof Construction Above Ground

KISARAZU Airfield on the eastern shore of TOKYO Bay was chosen to illustrate bombproof construction wholly above ground. The surrounding country is very flat and consequently the common method of using tunnels was impossible. In addition the elevation of the airfield is so close to sea level that underground construction would be costly. The airfield abounds in examples of various bombproof or protected structures. There are numerous small shops, blast walls, plane revetments, personnel shelters, command or operation posts, gasoline storage vaults, and other miscellaneous structures.

One of the best examples of bombproof construction at this airfield is a command post or operations post which is located outside the boundary of the airfield about 700 meters from the main gate. Enclosure (B) is a tracing furnished by the Japanese which indicates the principal dimensions, sections and type of construction. The structure is made up of alternate layers of concrete and earth. The innermost concrete layer is 1.5 meters thick and heavily reinforced; the next layer is earth 0.6 meters thick, over which a layer of rubble concrete 0.8 meters thick was placed. The entire structure was then covered with earth to a minimum depth of 0.6 meters on top and the area then seeded. How well camouflaged this command post was is illustrated in Figures 1 and 2.

The two entrances were arranged at diagonally opposite sides and were protected by blast walls, not only in front of the entrance but also on both sides. The side blast walls served a dual purpose, being constructed as buttresses to strengthen the vertical walls on the entrance sides of the structure. (Figure 2) The passageway leading from the entrance to the main room was constructed of concrete and fitted with a steel blast door (Figures 3 and 4).

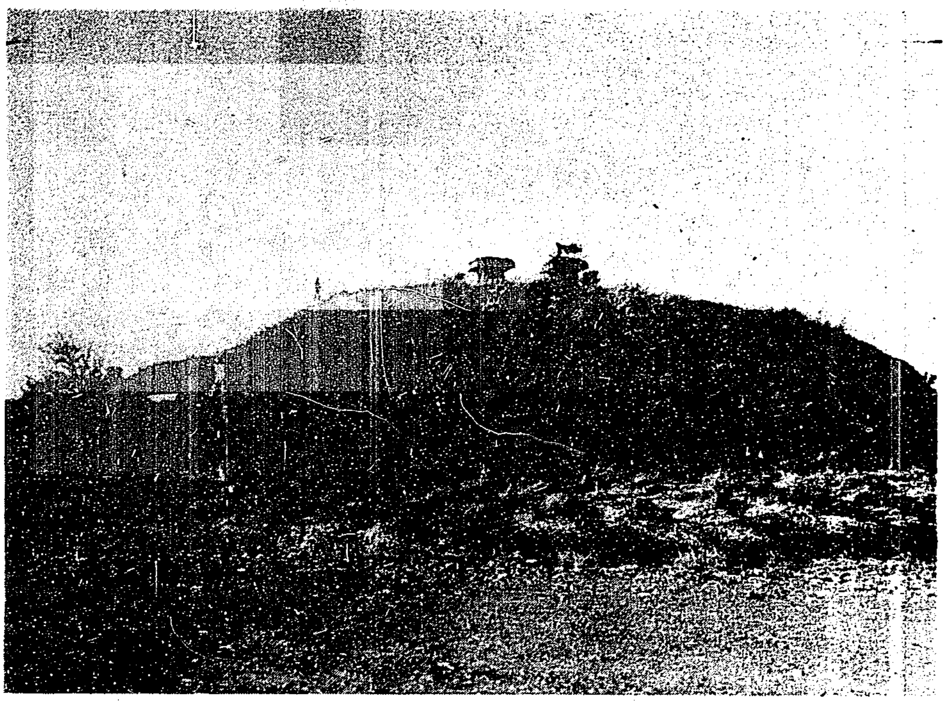


Figure 1
GENERAL VIEW OF COMMAND POST

Figure 2
VIEW OF ENTRANCE TO COMMAND POST

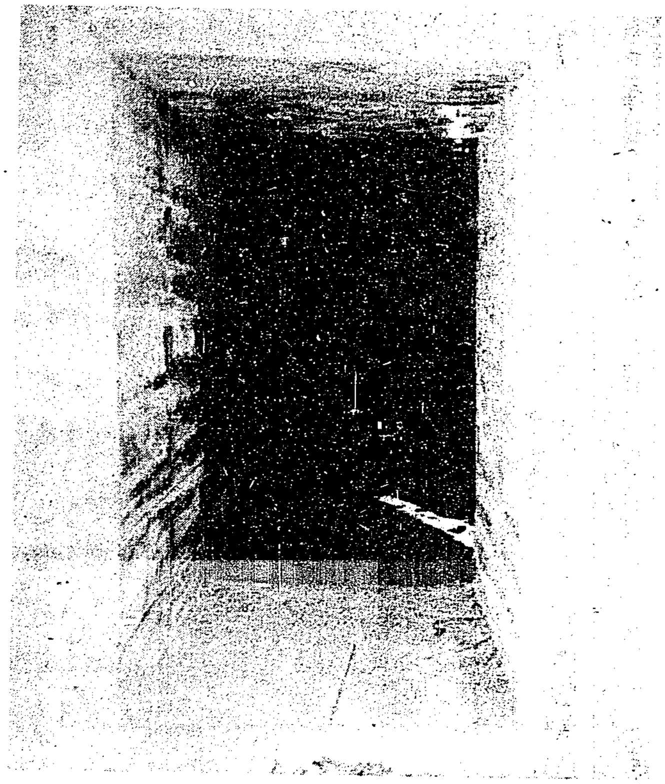


Figure 3
VIEW FROM MAIN ROOM OF COMMAND POST, LOOKING TOWARD ENTRANCE

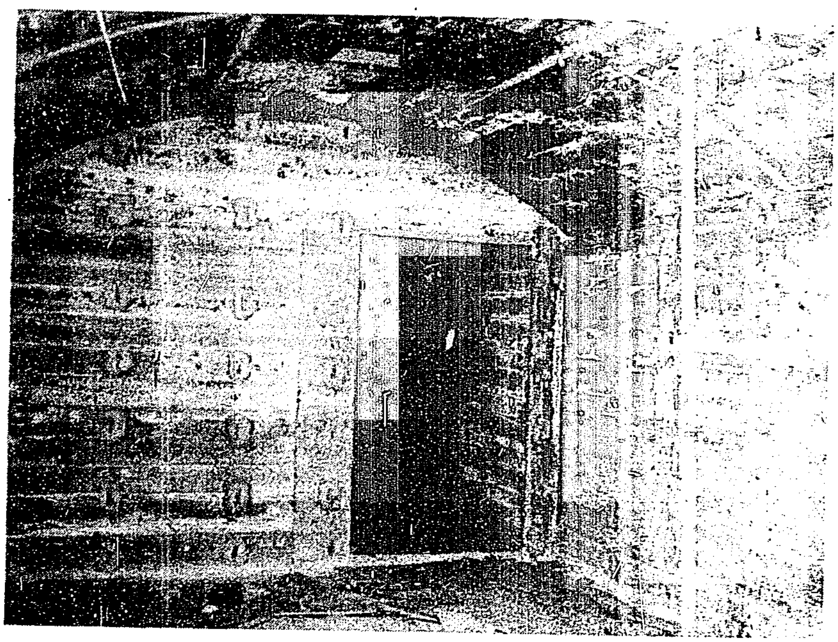


Figure 4
VIEW OF MAIN ROOM OF COMMAND POST

The main room measured 3m x 5m x 2.5m high in the center (Figure 4). It was ventilated by two vertical air shafts which were camouflaged on the exterior by earth-covered concrete caps.

This command post was designed to withstand the direct hit of a 500 pound bomb but was so well camouflaged that it made a very difficult target.

Of similar but much larger construction was the personnel shelter at KISARAZU Airfield. This earth covered structure was made up of a reinforced concrete arch of 3 meter span, 11.6 meter length and 1.5 meter thickness. The passageway leading into the main room was of reinforced concrete 0.3 meters thick. To give some protection against blast, this passage contained a right angle turn. The exterior entrance was set at right angles to the line of the passageway and was protected with a concrete blast wall and also earth fill. Enclosure (C) shows the details of this personnel shelter. In Figure 5 can be seen the blast walls protecting the two entrances and the strafing marks upon them. In addition, the two ventilating shafts protruding through the roof of the shelter can be seen.

The torpedo hangar at KISARAZU airfield is typical of some of the miscellaneous small shops which were dispersed about the airfield. The protection given this type of structure was not nearly as complete as that given the command post or personnel shelter mentioned above. This earth covered torpedo shop or hangar was made up of a very flat reinforced concrete arch 0.8 meters thick springing from side walls of the same thickness. The working space furnished was 3.5 meters in width by 15 meters in length. The entrance was provided with steel blast doors but no other protection was given along or at the entrance to the short passageway leading from the main working space to the exterior. A plan with sufficient sections to illustrate the construction is shown as Enclosure (D). Although the torpedo hangar is well built, it is doubtful whether it would offer very much protection against a direct bomb hit. The value of this type lies in the protection it would afford agains incendiary bombs and blast.

The torpedo shed at KISARAZU airfield is of unusual design, entirely different from other protected structures at the station. The structure is 34 meters long and is made up of a series of rectangular concrete bents spaced two meters on centers. The walls and floor are of concrete while the remainder is made up of timber beams and pine planking. Mr. TSUDA, who accompanied the field team, could not explain the reason for this unorthordox roof construction. He was certain, however, that lack of concrete was not the reason. The structure may have been designed originally as a storage pit with a portion of the roof purposely left uncovered. As built, it was covered with approximately one meter of earth and provided with two exits. One entrance at the end of the structure was protected by earth revetments; near the opposite end a side entrance was provided and protected by timber bulkhead which was backed with earth fill. The end entrance is shown on the extreme right of Figure 5. Figure 6 is interior view of the structure showing the concrete bents and timber and concrete roof. For plans of this structure see Enclosure (E).

Amidst the ruins of the Japanese Navy Minstry in TOKYO, there stands a bombproof pumping station which came through the air raids unscathed. Figure 7 shows the structure and adjacent damaged buildings.

The pumping station was built of reinforced concrete in the form of a semicircular arch of 2.8 meter radius and 0.6 meter thickness. The top of the arch was capped with additional concrete, bringing the structure to a peak, and thus creating a better bomb deflecting surface. Entrances at both ends of the pumping station were protected by massive blast walls and roof slabs (see Figure 8).

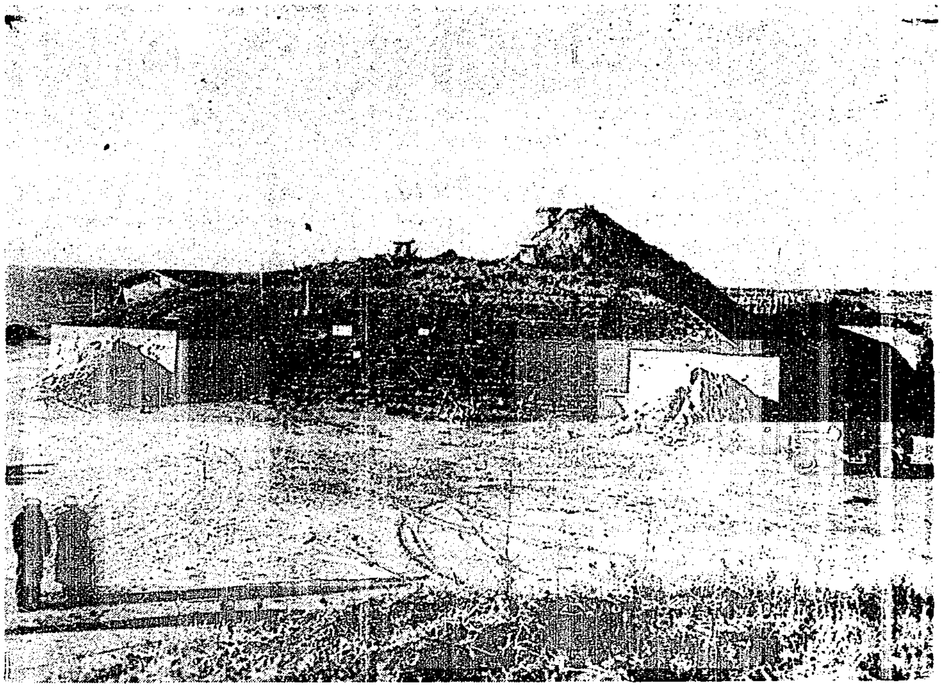


Figure 5
GENERAL VIEW OF PERSONNEL SHELTER

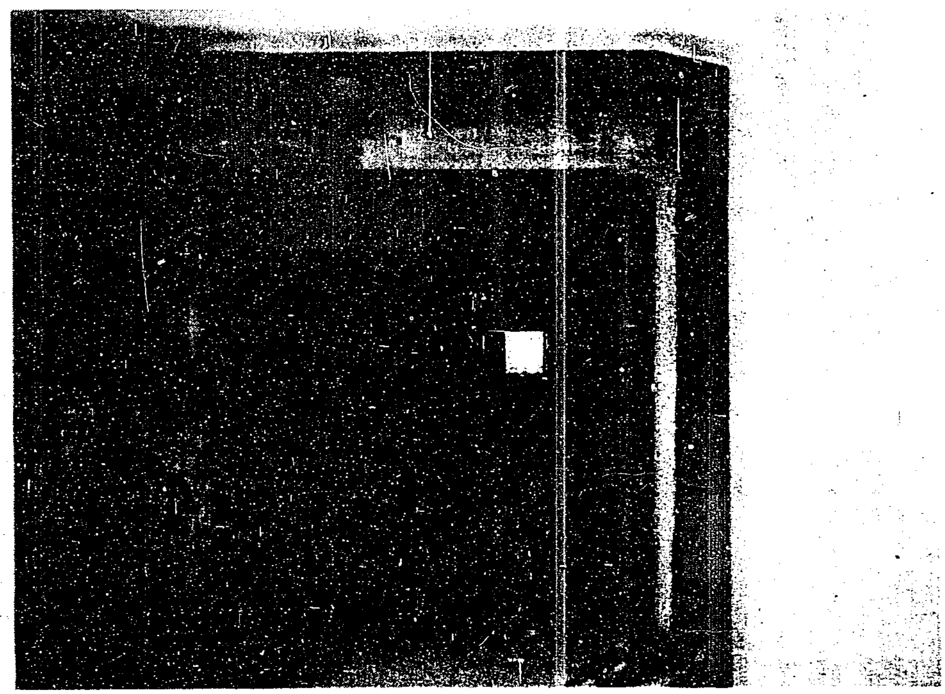


Figure 6
INTERIOR VIEW OF TORPEDC SHED

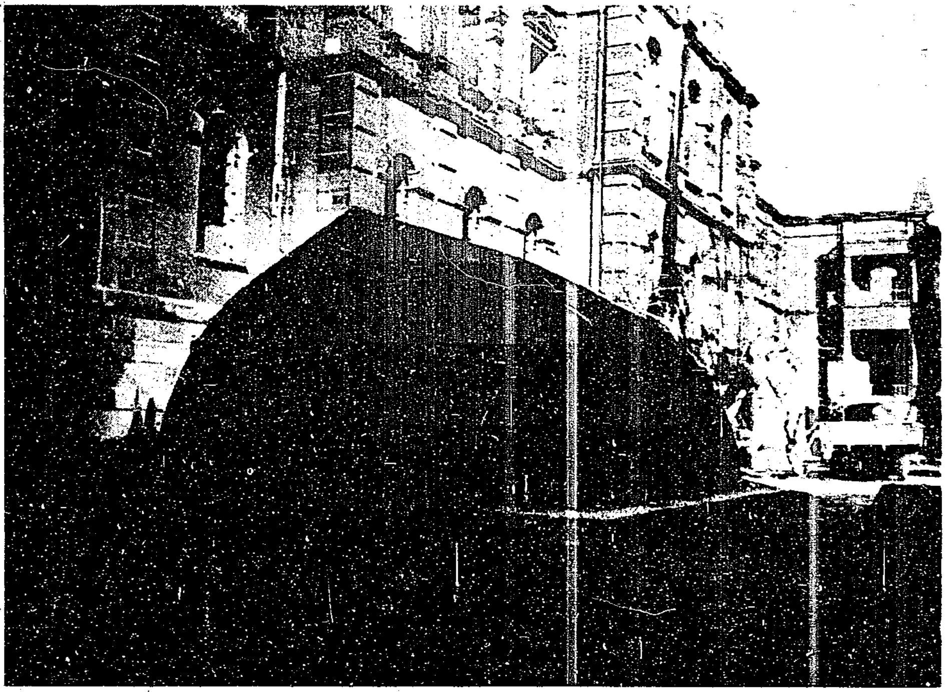


Figure 7
GENERAL VIEW OF PUMPING STATION

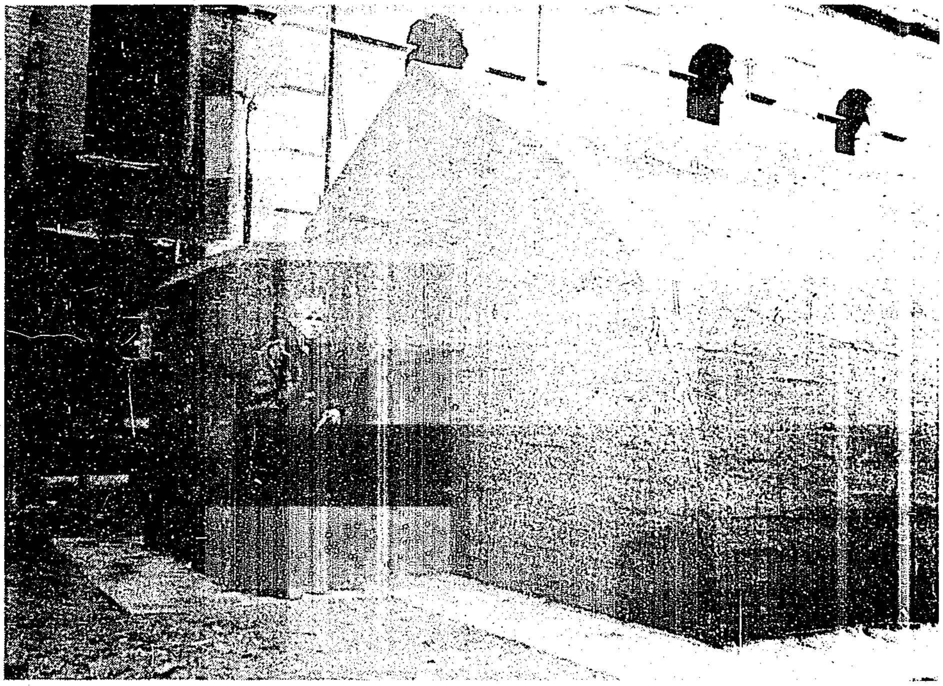


Figure 8
ENTRANCE TO PUMPING STATION

A sketch of the structure with principal diminensions and sections is given in Enclosure (F). For interior views see Figures 9 and 10.

At KISARAZU Airfield two examples of protection of aviation gasoline storage facilities were found. The first was constructed of reinforced concrete covered with earth. The roof thickness was only about 0.5 meters in thickness and would offer little protection against bomb hits; its only value would be to protect the gasoline supply against fire. The structure housed three tanks of approximately 70 cubic meters each. See Figure 11 and 12 for views of this storage vault.

Brick gasoline storage vaults are included in this report only to show a trend in the methods of applying bombproof treatment to structures. The brick arch of the vault shown in Figure 13 was only 0.45 meters thick and would offer only very little protection. It was intended to cover the structures with earth but the entire project was abandoned before all of the vaults had been completed (see also Figure 14).

The storage of aviation gasoline above ground creates one of the worst hazards at an airfield, and why the Japanese spent money on such feeble protection of gasoline stores which properly belong below ground, could not be determined.

Another type of bombproof construction observed at KISARAZU Airfield was plane revetments. These structures were erected parallel to the runways and served to disperse and protect fighter planes and still have them available for quick takeoffs. See Figure 15 for general view of these plane revetments.

The revetment was made up of two concrete arches of varying span which served to fit the shape of the aircraft. The front of the structure was provided with a concrete curtain wall for protection against strafing. Figure 16 which is a front view shows strafing marks on the curtain wall. The entire structure was covered with earth and camouflage nets were used over the entrances.

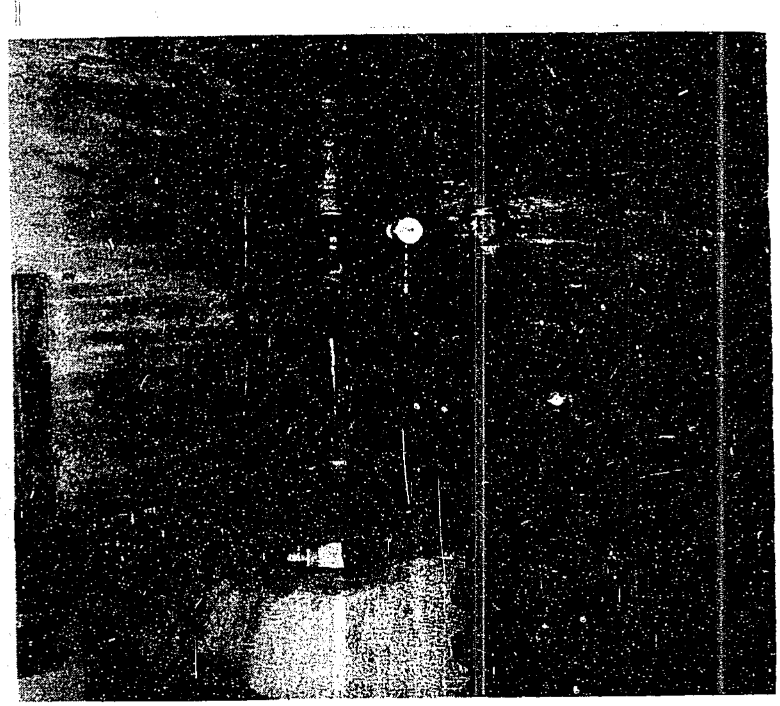
Some structures were protected with concrete blast walls or sand-filled concrete shells as illustrated in Enclosure (G).

Other structures were protected with timber retaining walls backed with earth as in the case of the torpedo hangar described previously. In general, bombproof structures were provided with reinforced concrete blast walls across the entrances. A novel type was discovered at YOKOSUKA Airfield. Here, across the front of a concrete tunnel of 20 meter span, ran a narrow gage railroad track on which small flat cars topped with concrete blast walls were set. It was relatively easy to set these walls in place in the event of a raid. Their real value, however, was in camouflaging the entrance since a relatively small overturning moment, due to bomb blast, would without a doubt upset them. See Figures 17 and 18 for samples of blast walls of earth construction.

D. Underground Bombproof Construction in Tunnels and Caves

When the Japanese realized that the home islands were vulnerable to air attacks they began to disperse certain critical industries. The simplest yet most effective method was the use of tunnels and caves, since the terrain lends itself so well to this type of construction. Probably the most critical industry was that dealing with manufacture of aircraft parts, and the Navy Ministry alone had constructed over 130,000 square meters of underground aircraft manufacturing space in tunnels. In addition an equal amount of semi-underground construction also was realized. Enclosure (I) is a chart indicating some of the underground installations for aircraft manufacture. In addition caves and tunnels were used for every conceivable purpose: storage, personnel shelters, aircraft hangars, etc.

Figure 9
INTERIOR VIEW OF PUMPING STATION



rigure 10
INTERIOR VIEW OF PUMPING STATION

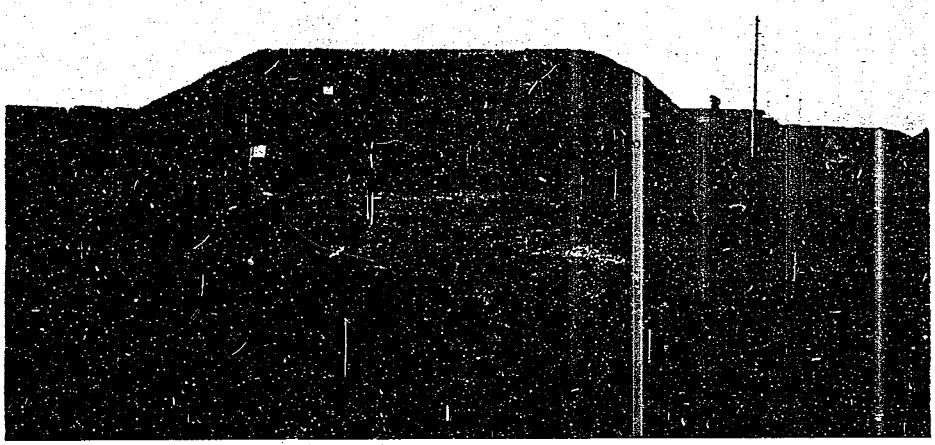


Figure 11
EXTERIOR VIEW OF CONCRETE GASOLINE STORAGE VAULT

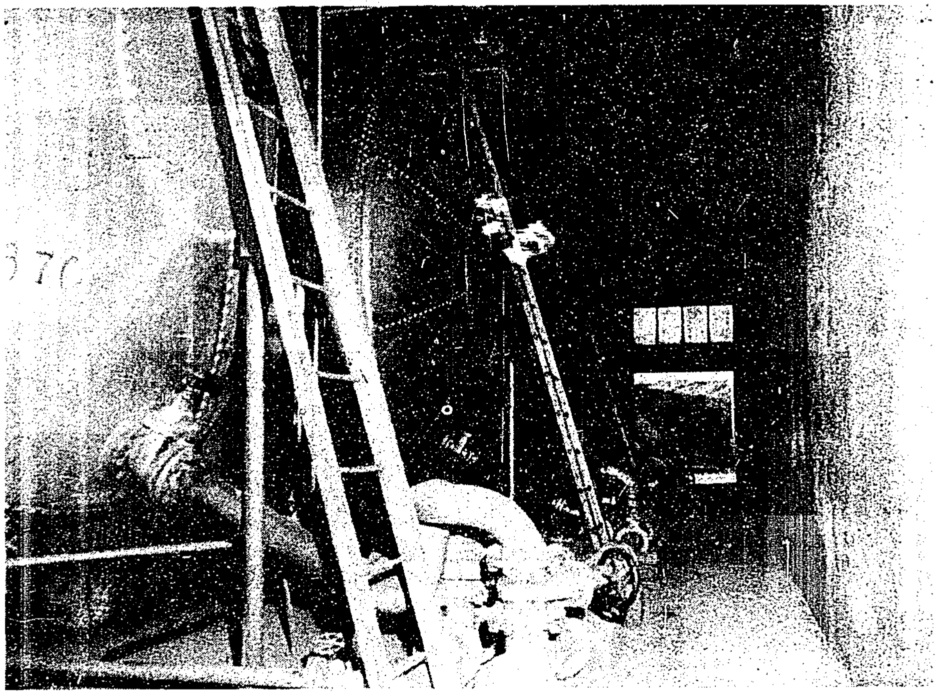


Figure 12
INTERIOR VIEW OF CONCRETE GASOLINE STORAGE VAULT

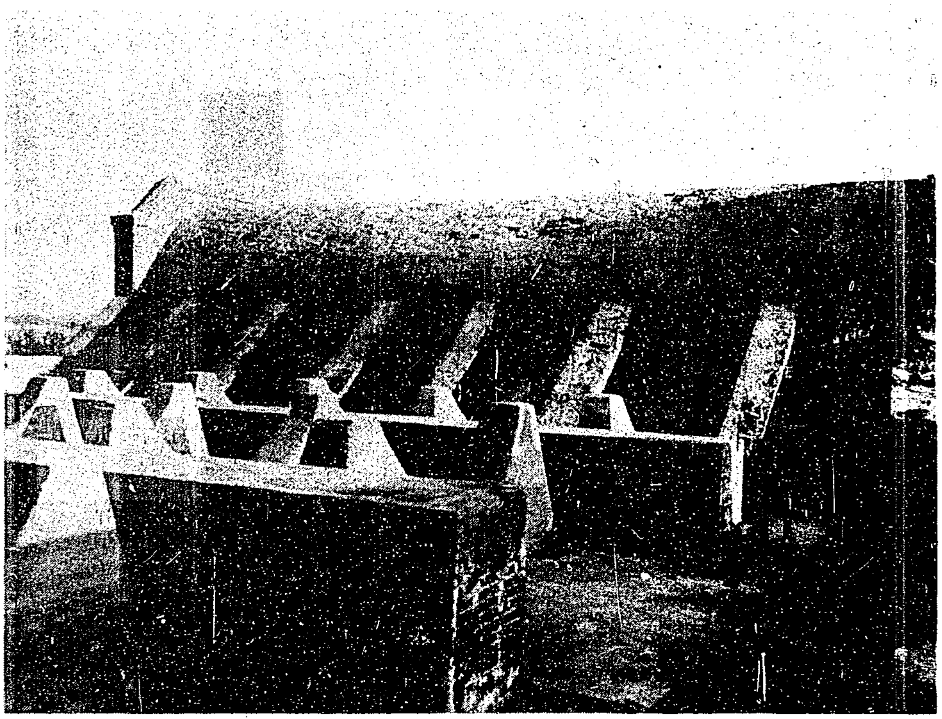


Figure 13

EXTERIOR VIEW OF BRICK GASOLINE STORAGE VAULT

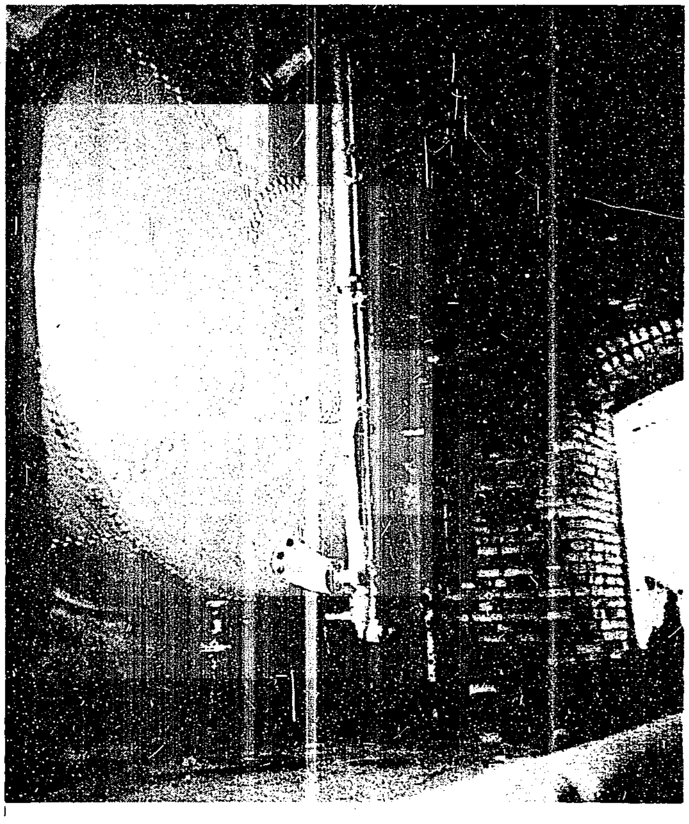


Figure 14

INTERIOR VIEW OF BRICK GASOLINE STORAGE VAULT

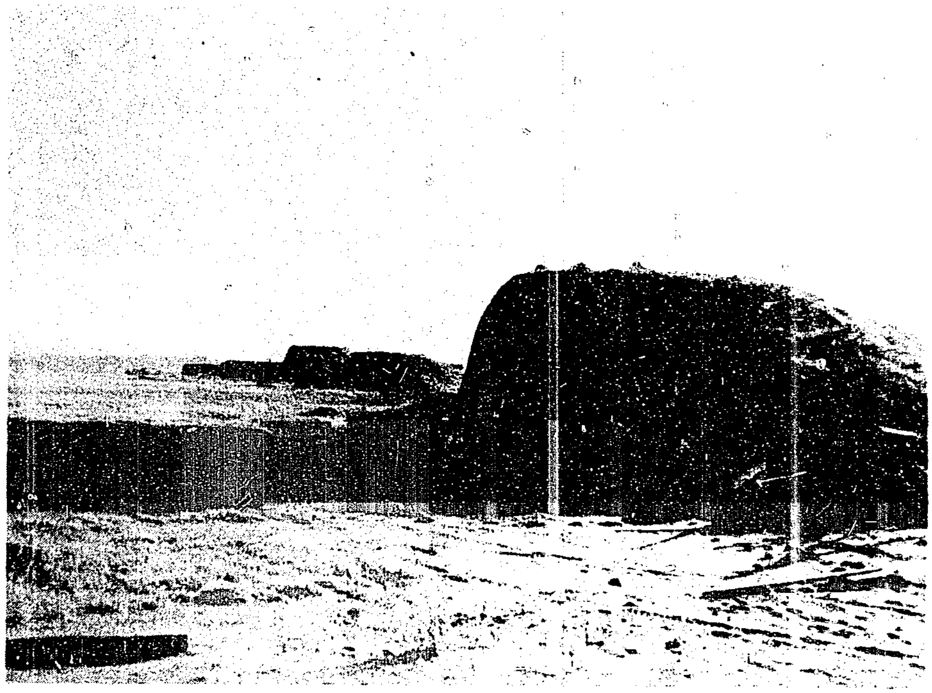


Figure 15
PLANE REVETMENTS AT KISARAZU AIRFIELD

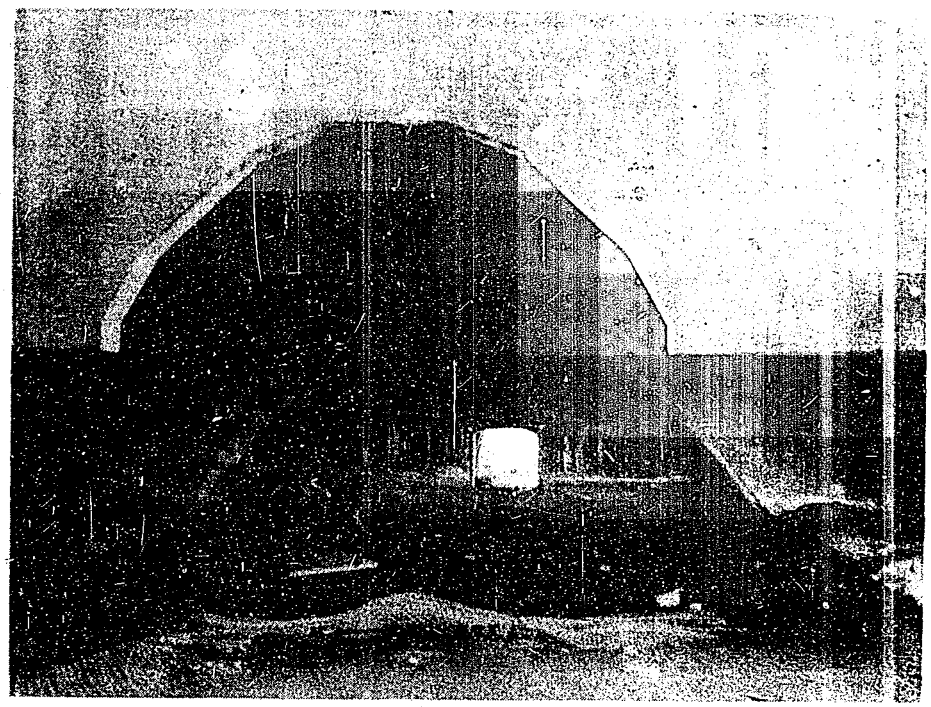


Figure 16
FRONT VIEW OF PLANE REVETMENT

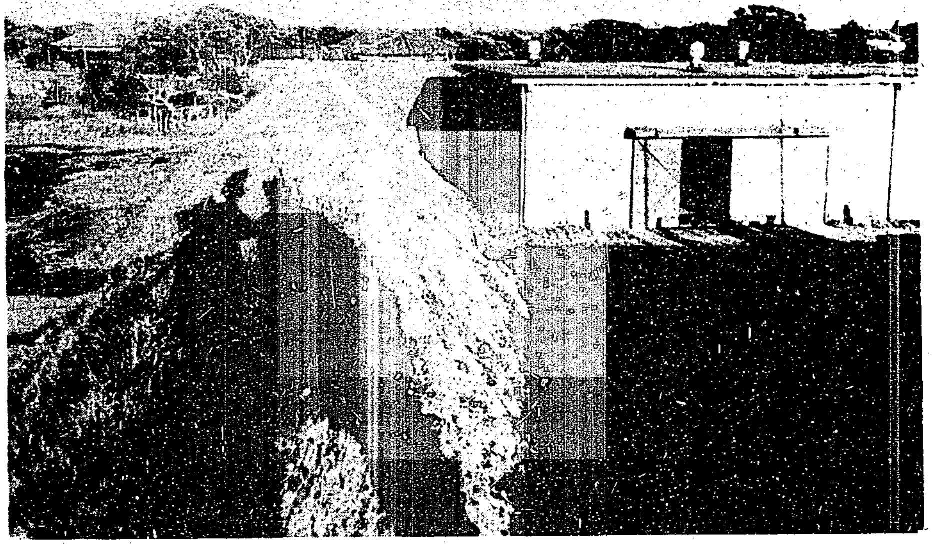


Figure 17
BLAST WALLS

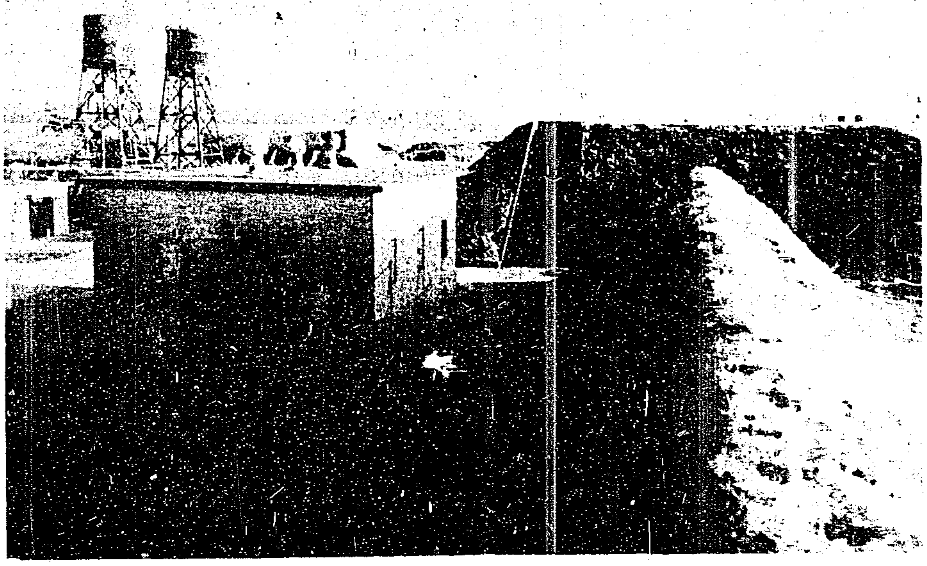


Figure 18
BLAST WALLS

In order to present a fair cross section of bombproof tunnel construction, two sites of extensive tunnel work were visited and these examples will be discussed in detail. The first example deals with tunnels at OAMI, the second with the tunnels at YOKOSUKA Airfield.

One of the main dispersal plants of the Hitachi Aircraft Company of CHIBA was about one mile north of village of OAMI. Located in very hilly country and very cleverly concealed, it offered an extremely difficult target for enemy aircraft. Figures 19 and 20 show the type of terrain and the absence of any visual disturbance due to the extensive construction carried on there.

The project dealt with two main types of installations, namely, the tunnels and the earth-covered huts. The latter are discussed in NavTechJap report "Design of Japanese Structures" Index No. X-33. Enclosure (H) is a general drawing indicating the scope of the work which was commenced in March 1945. and completed in July the same year at a cost over 4,000,000 yen. Mr. IITSUKA, former commander of the 3015 Construction Battalion, was in charge of the construction.

At OAMI, there were constructed five tunnel blocks totaling about 2840 meters in length and affording approximately 10,690 square meters of floor space. Tunnel block data is listed below:

Block No.	Length (meters)	Area (square meters)	Remarks
1	380	1450	Manufacture of fuselage parts.
2	950	3640	Manufacture of fuselage parts.
3	600	2200	Assembly of fuselage framework.
4	730	2760	Assembly of fuselage framework.
5	180	680	Manufacture of jigs and tools.
Total	2,840 meters	10,730 square meters	

The tunnel headings were dug through shale so that little shoring was necessary and approximately six meters of tunnel could be finished in 24 hours by three shifts of about 13 men each. Enclosure (J) is a typical tunnel cross section showing the method of framing tunnel lining, method of providing drainage, and principal dimensions. A typical tunnel entrance is shown in Figure 21 and typical tunnel interiors are shown on Figures 22 and 23.

These tunnels were very damp and poorly ventilated. Corrosion on machinery must have been extremely high. Working conditions in these tunnels were poor and only in a country like Japan could people be forced to work under such conditions. But this type of tunnel is typical of the thousands of tunnels dug into the hillsides.

At TATEYAMA and YOKOSUKA Airfields there was a type of tunnel designed for the storage of operating aircraft. Enclosure (K) shows typical sections of the tunnel construction at TATEYAMA Airfield and Figure 24 shows the tunnel entrance.

A detailed investigation was made of a similar tunnel at YOKOSUKA Airfield. Adjacent to the airfield are three prominent hills, NAJIMA, NATSUJIMA and NATAKIRIYAMA, all of which contained extensive tunneling. Figures 25 and 26 are general views of one of these hills. Investigation was centered on the concrete arch tunnel through NAJIMA Hill which is probably one of the largest span tunnels in the Orient.

Figure 19

GENERAL VIEW OF SITE OF HITACHI AIRCRAFT CO. AT OAMI

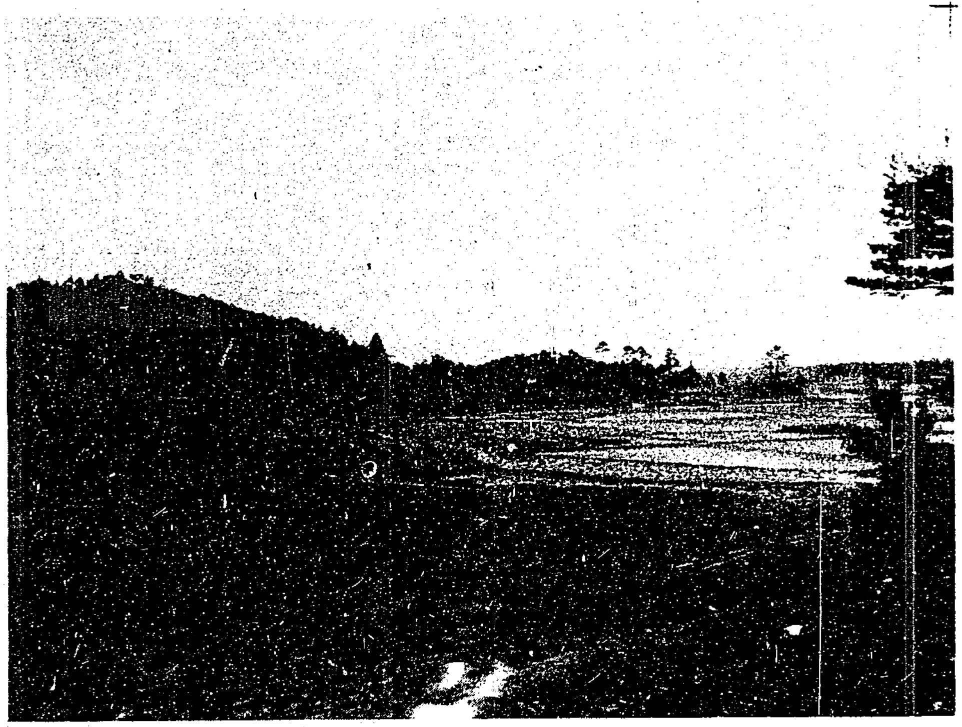


Figure 20

GENERAL VIEW OF SITE OF HITACHI AIRCRAFT CO. AT OAMI

Figure 21
TYPICAL TUNNEL ENTRANCE, HITACHI AIRCRAFT CO. AT OAMI

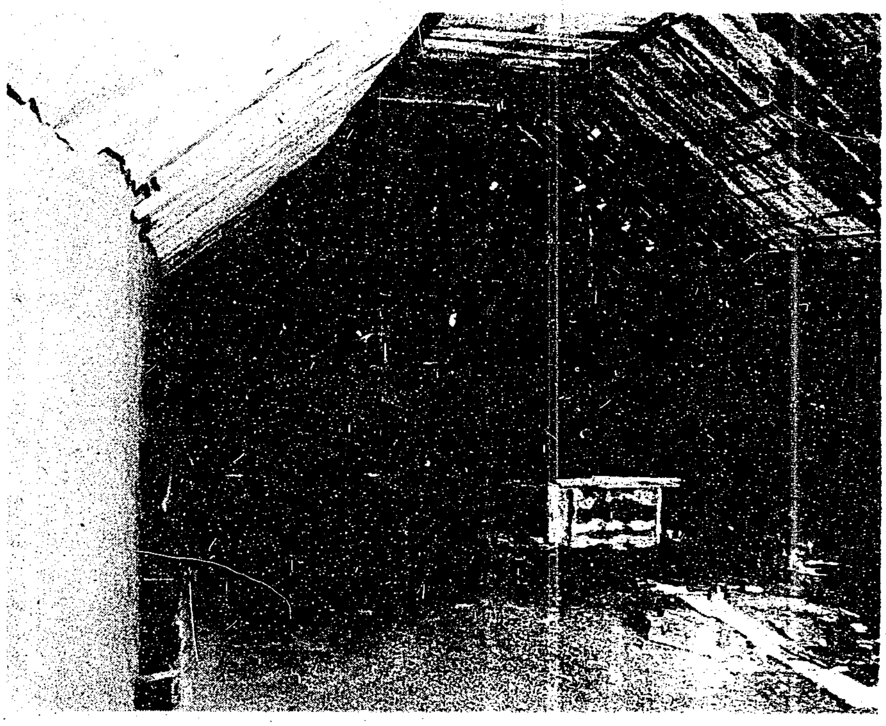


Figure 22
TUNNEL INTERIOR, HITACHI AIRCRAFT CO. AT OAMI

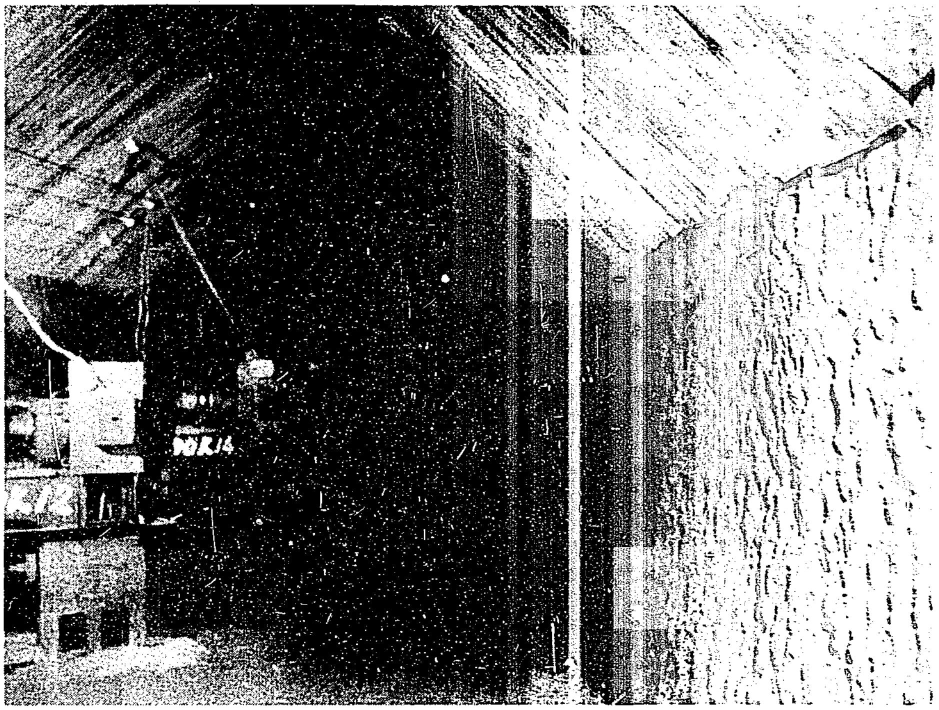


Figure 23
TUNNEL INTERIOR, HITACHI AIRCRAFT CO. AT OAMI

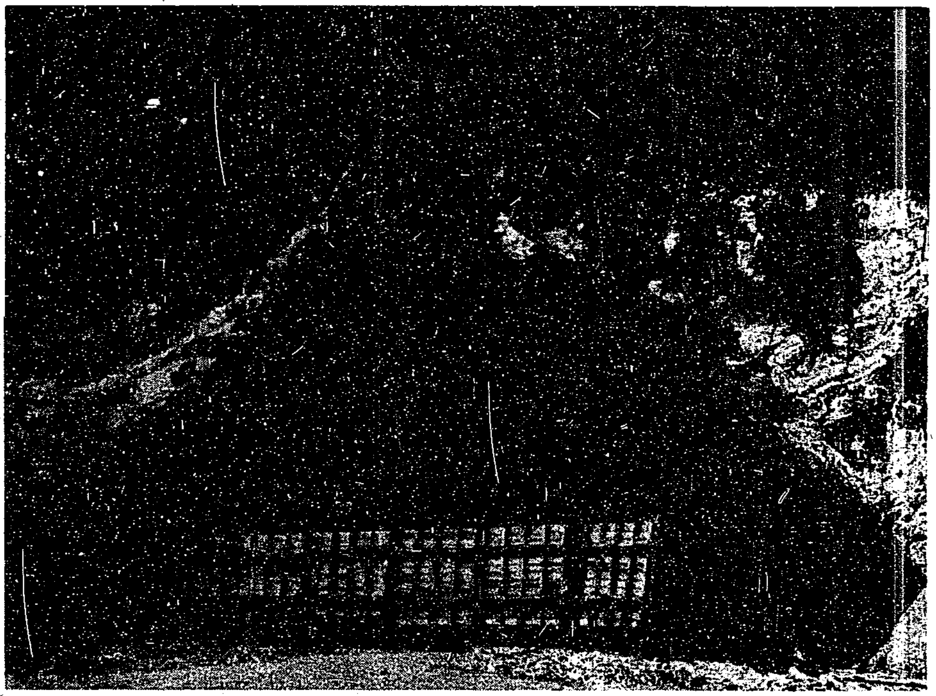


Figure 24
AIRCRAFT TUNNEL AT TATEYAMA AIR BASE

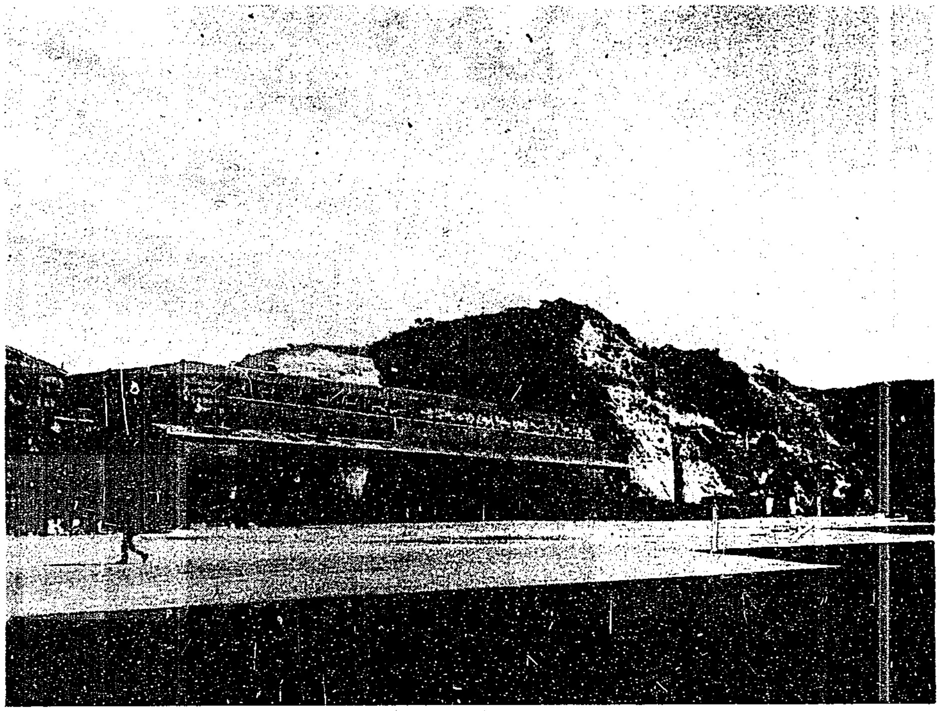


Figure 25
GENERAL VIEW OF NATAKIRIYAMA HILL, YOKOSUKA AIRFIELD

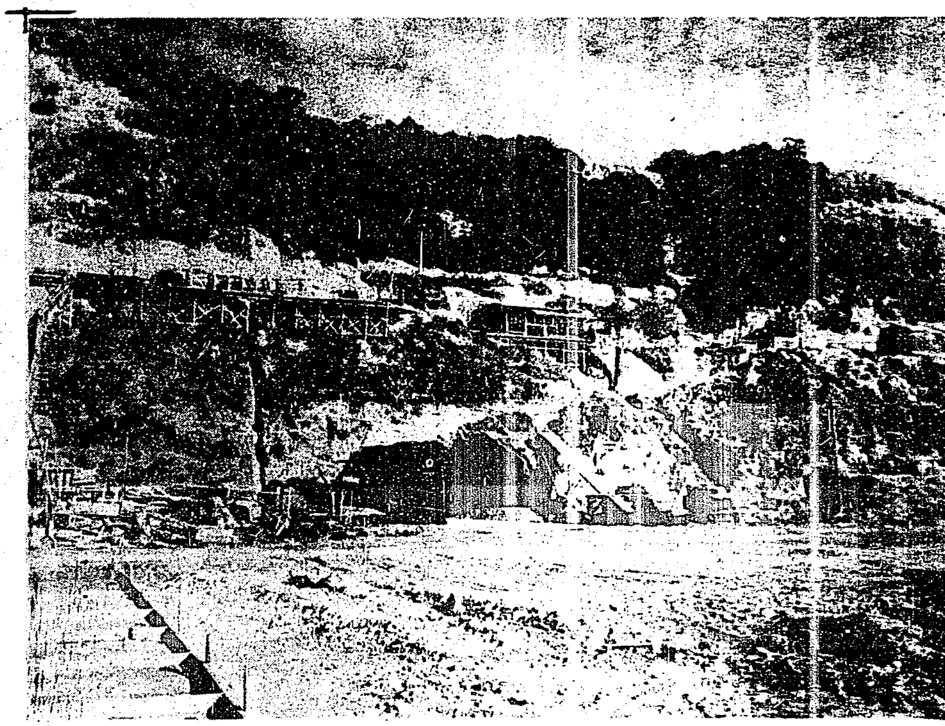


Figure 26
TUNNELS IN NATAKIRIYAMA HILL, YOKOSUKA AIRFIELD

Enclosure (L) gives the overall dimensions and arch details. The tunnel ends are of 20 meter span for distances of 80 meters and 70 meters, the center portion is of 13 meter span for a distance of 100 meters, making the total tunnel length 250 meters. The tunnel ends are of concrete arch construction, whereas the center portion is unlined and unsupported. A serious shortage of cement and lack of time were the reasons for not lining the center portion.

Since construction was entirely through shale, it was possible to construct the arches without the use of shoring. To accomplish this,,five tunnel heads were driven, two at the springing line of the arch, two half way up on the arch, and one at the crown. Similar tunnel heads are illustrated in Enclosur (K). As the headings progressed it was possible to follow with the concrete forming and pouring of the arch itself. Upon completion of the concrete arch, a sixth heading was driven at floor level directly below the crown for the purpose of excavating the material beneath the arch. This heading measured approximately 2m x 3m and was fitted with a double track to speed the excavation. This method of arch construction is a simple yet inexpensive way of eliminating shoring, but is only possible in material similar to the shale encountered near YOKOSUKA. The concrete arch itself appears to be rather flat and is made up of three simple curves of two different radii.

The center section of the tunnel, unlined and unsupported, is of 13 meter span, and fears were expressed as to whether this arch would be self-sustaining.

Work commenced on this tunnel on 10 January 1945 and was completed on 14 August 1945. From 400 to 600 men were employed on this operation, which was under the supervision of Lieut. Masao YAMAMOTO, construction battalion commander at YOKOSUKA Airfield. Over 24,000 cubic meters of shale were excavated and approximately 13 tons of explosives were used; of this total about eight tons were dynamite and approximately five tons were a mixture of liquid oxygen and charcoal powder. The arch itself involved the use of 24,000 cubic meters of concrete. Figures 27, 28, 29, 30, and 31 illustrate this type of tunnel.

Many other tunnels exist at YOKOSUKA Airfield but they are not of unusual design or construction and their general type has been discussed under the tunnels at OAMI.

E. Underground Bombproof Structures Specially Constructed

Examples of specially constructed bombproof structures below ground are rare in Japan because of the tremendous expense involved in using specially trained help and critical materials. The intended use of such structures would of necessity be confined to the most vital activities. The Underground Headquarters of the Imperial Japanese Navy probably is the best example of this type of bombproof construction. This structure contained direct communication lines to all the Naval Districts and in addition had adequate radio facilities. It was built adjacent to the Imperial Navy Ministry in TOKYO, which was completely destroyed during the May 1945 raids.

Although it was stated that all plans for this project were secret and had been destroyed, a partial set was obtained from the Shiraishi Foundation Co., prime contractor on this structure. These plans, which contain sufficient information to reproduce the structure, are listed in Enclosure (A) and have been forwarded to the Washington Document Center. Enclosure (M) is a general drawing of the Underground Headquarters. Also Figures 32 through 46.

The structure was designed to withstand the direct hit of a 5000 pound bomb and was so well protected that it is felt it could withstand a great deal of punishment. The main structure measured 33 meters by 14 meters by 13.9 meters deep and from ground level to the bottom the structure measured 17.1 meters. An explosion mat of reinforced concrete was placed over the roof and a second explosion mat also 1.5 meters thick of plain concrete was added. This latter slab extended above the ground one-half meter.

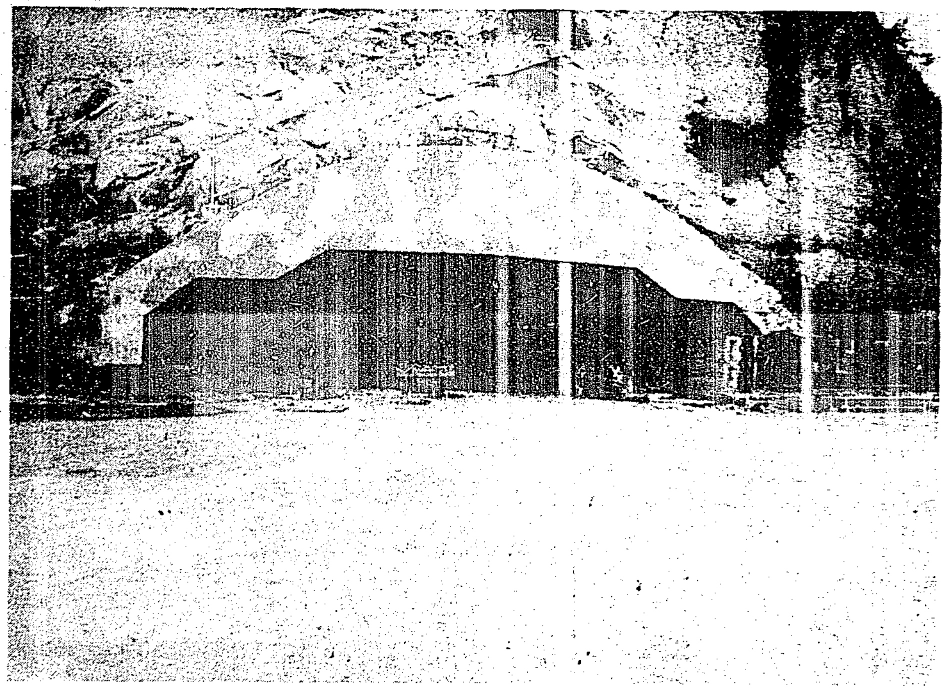


Figure 27
TUNNEL ENTRANCE AT YOKOSUKA AIRFIELD

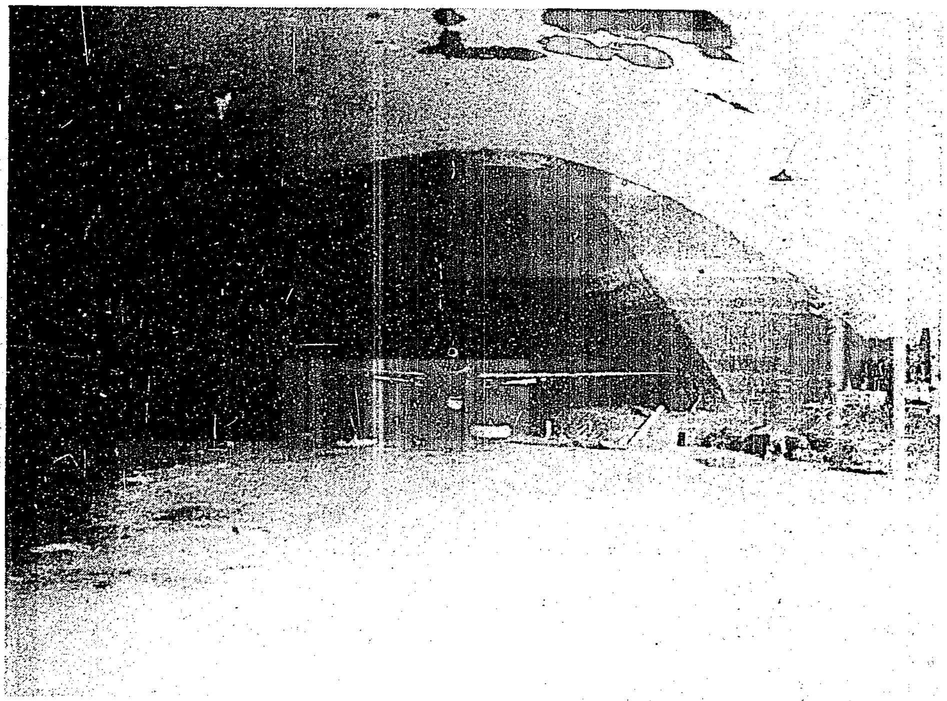


Figure 28
MAIN CONCRETE ARCH AND UNLINED CENTER ARCH, YOKOSUKA AIRFIELD

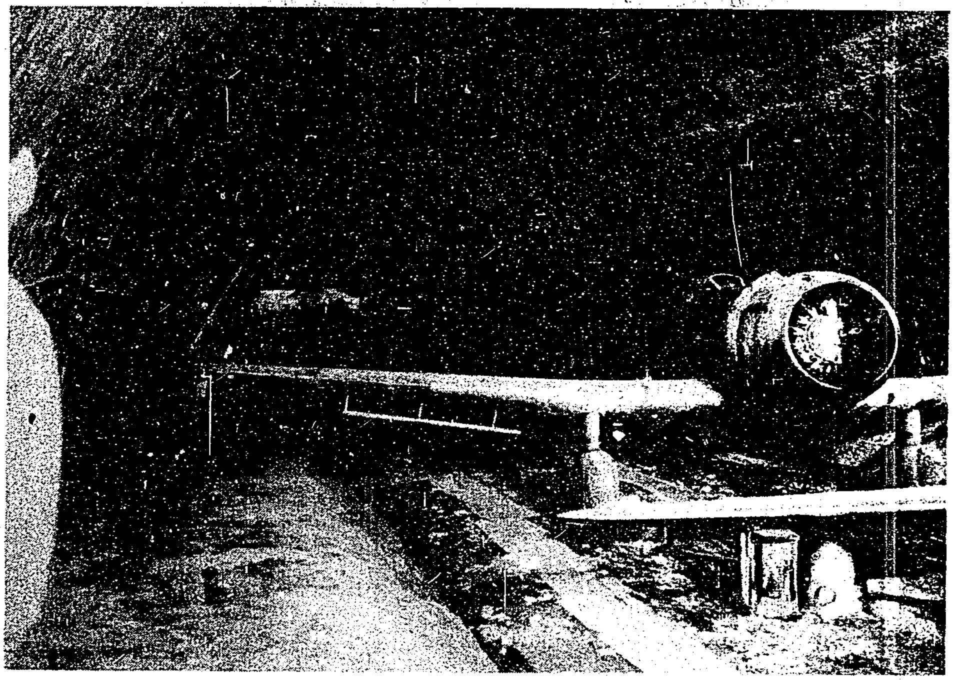


Figure 29
UNLINED CENTER ARCH, YOKOSUKA AIRFIELD

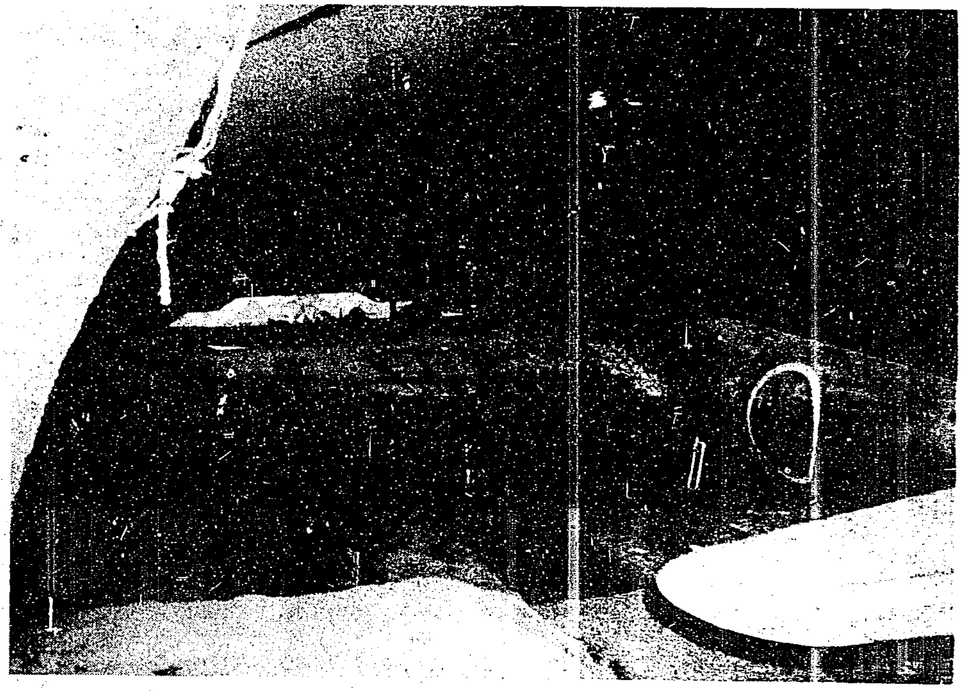


Figure 30
VIEW LOOKING FROM UNLINED TUNNEL SECTION TOWARD LINED SECTION, YOKOSUKA AIRFIELD

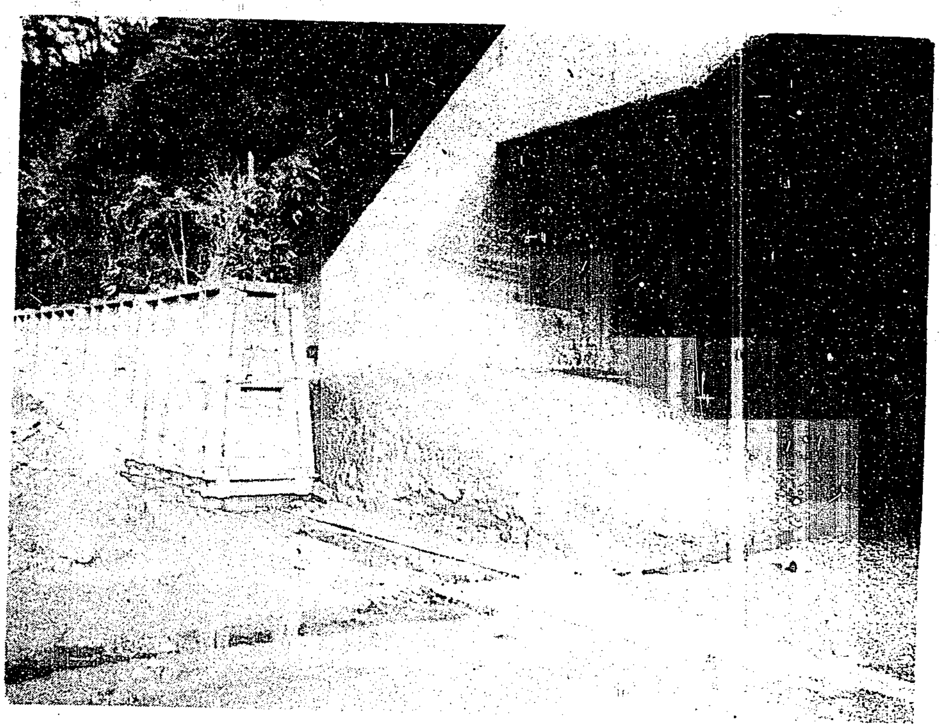


Figure 31

BLAST WALLS AT TUNNEL ENTRANCE, YOKOSUKA AIRFIELD

The contract for the structural design and erection of this structure was awarded to the Shiraishi Foundation Company, one of the largest and best qualified firms in Japan. It had previously done such jobs as foundation for docks and some of the larger building in TOKYO, and was a leader in the field. The soil, being very homogeneous, was suitable for supporting this structure by the concrete caisson method. The main portion of the building therefore was designed as a cassion. Care was taken in the sinking to eliminate vertical joints in the pours. Work was carried on continuously and was completed in 1942, about one year after its inception.

Four main entrances to the structure were built after the caisson was in place. These approaches provided four widely separated exits from the building. Since the completion of the structure two defects have been noted in the design of these approaches. In the first place, the approaches should have been built with right angle turns for blast protection. In the second place, they should have been set on piles, since cracks have appeared at the juncture with the main caisson due to the settlement of the approaches, which are in effect very long cantilever beams. Because of the mass of the structure it is extremely waterproof; although the lower story had a few inches of water, this could be taken care of if the structure were in continual use. The upper two stories were very dry in contrast to the tunnels which had been visited.

The following data give some idea of the mass of this structure. Over 210,000 kg of reinforcing steel was used in the main caisson. In the approaches approximately 34,000 kg of reinforcing steel was employed. The explosion mat which measured 40m x 21 m x 1.5m contained 260 cubic meters of concrete and over 138,000 kg of steel.

The Underground Headquarters was equipped with power; heating and ventilation, drainage facilities, and fresh water. The main power supply was furnished from the nearby Ministry but there were in addition two gasoline motor driven generators of 6 kva, each of which served as standby power sources. This emergency supply would not allow for full operation of the Headquarters, and this lack of planning for adequate standby power supply could defeat the whole purpose of the structure. The heating and ventilating system was well designed. Ventilating intake ducts were well protected and well dispersed. The intake air was led to a room in the lowest story and passed through a bank of six air filters. It then passed into the blowers and from there through two heaters and thence into the distribution system. The air filters were arranged in such a way that they could be bypassed singly or used in any combination. In the same room with the ventilating equipment there were provided two small centrifugal pumps which furnished all the drainage necessary. The first pump had a capacity of 0.36 cubic meters per minute at 1430 RPM; the second pump had a capacity of 0.72 cubic meters per minute at 1450 RPM. Both pumps were made by the Ozuma Pump Co. of TOKYO. Toilet facilities were non-existant and only one lavatory was installed. Thus the facilities provided were just sufficient to get by and would never meet the standards used in the United States. This is true of most construction in Japan where the convenience, comfort, and often the well-being of the individual are relegated to the background.

The intended use of the Underground Headquarters can best be shown by a detailed description of the main rooms in the structure. The first or top story contained five main rooms approximately 4m x 5m each with a small anteroom 2m x 4m on each end. All of the main rooms were inter-connected, this being the only means of egress. The rooms served as operations offices. The second deck was called the military section and was made up of five main rooms of the same size as those on the first deck, but corridors were provided on both sides running the full length of the structure. The first room was used as a shelter with a capacity of 100 persons, the second room was a communications office, the third an operations office, the fourth a decoding office, and the fifth room was a telephone exchange. The third deck contained four main rooms: two communications centers, commanding officer's headquarters, and a machinery room containing heating and ventilating equipment and drainage pumps. All of the rooms were ventilated and adequately lighted. The room entrances were fitted with heavy steel blast doors and on the bottom two decks means of egress were simple and adequate.

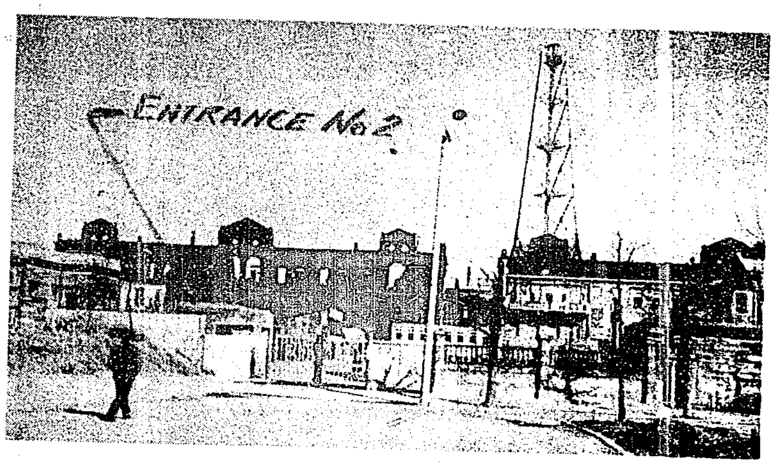


Figure 32

GENERAL VIEW OF JAPANESE NAVY MINISTRY IN RELATION TO ENTRANCE NO. 2 OF UNDERGROUND HEADQUARTERS

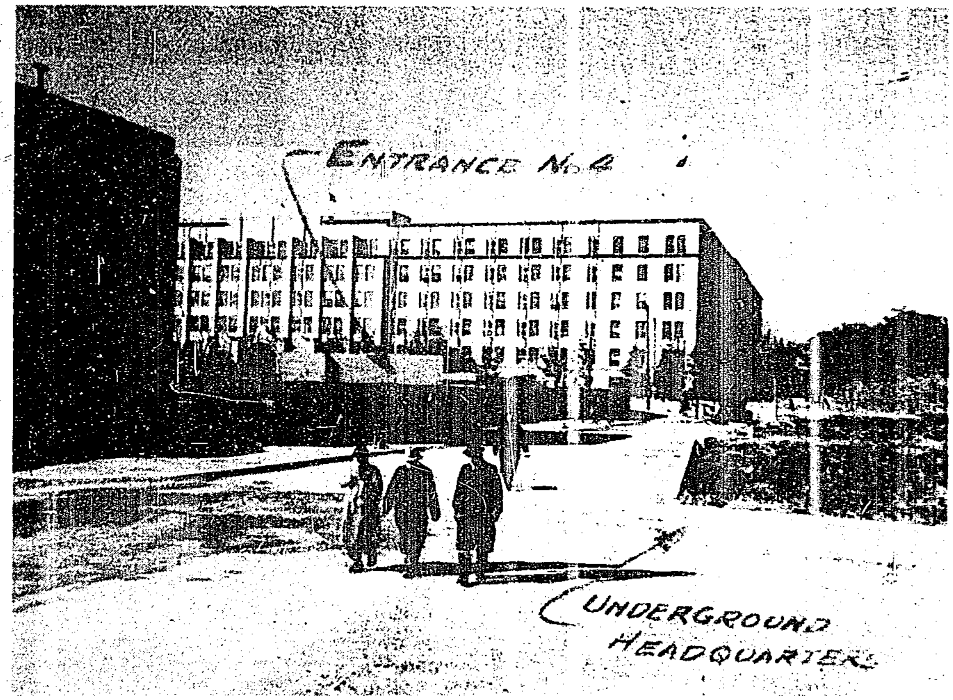


Figure 33
ENTRANCE NO. 4, UNDERGROUND HEAD-QUARTERS, JAPANESE NAVY MINISTRY

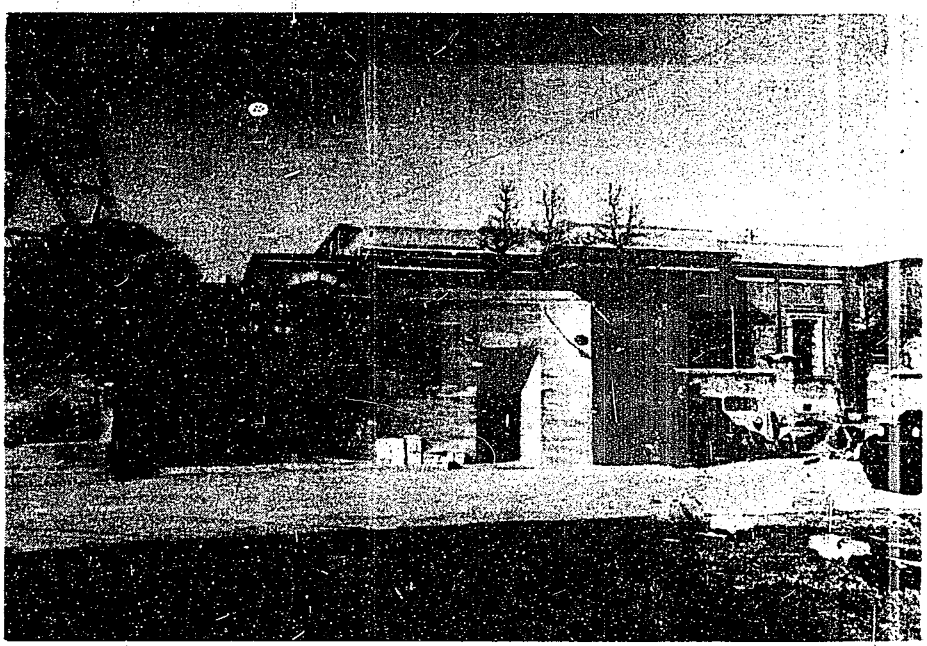


Figure 34
ENTRANCE NO. 2, UNDERGROUND HEAD-QUARTERS, JAPANESE NAVY MINISTRY

Figure 35

STAIRWAY LEADING FROM ENTRANCE NO. 2, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

Figure 36

STAIRWAY BETWEEN 1st AND 2nd DECKS, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

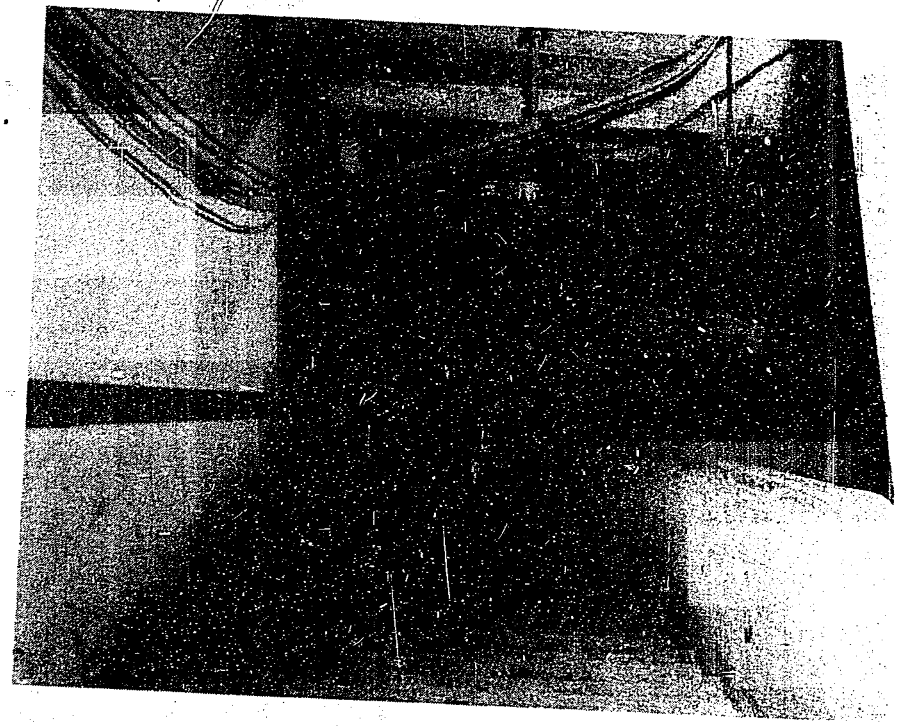


Figure 37

STAIRWAY TO 3rd DECK, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

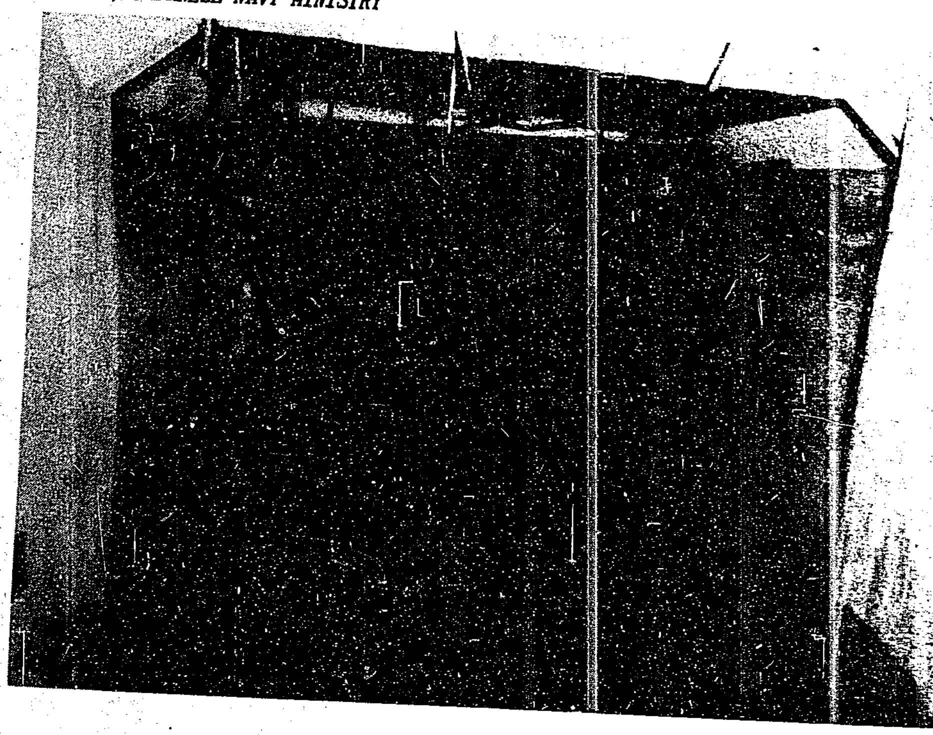


Figure 38

DOUBLE BLAST DOORS AT FIRST DECK, ENTRANCE NO. 3 - UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

Figure 39

MAIN ROOM ON 1st DECK, SHOWING VENTILATING DUCTS - UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

Figure 40

SHOWING INTER-CONNECTING MAIN ROOMS, 1st DECK - UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

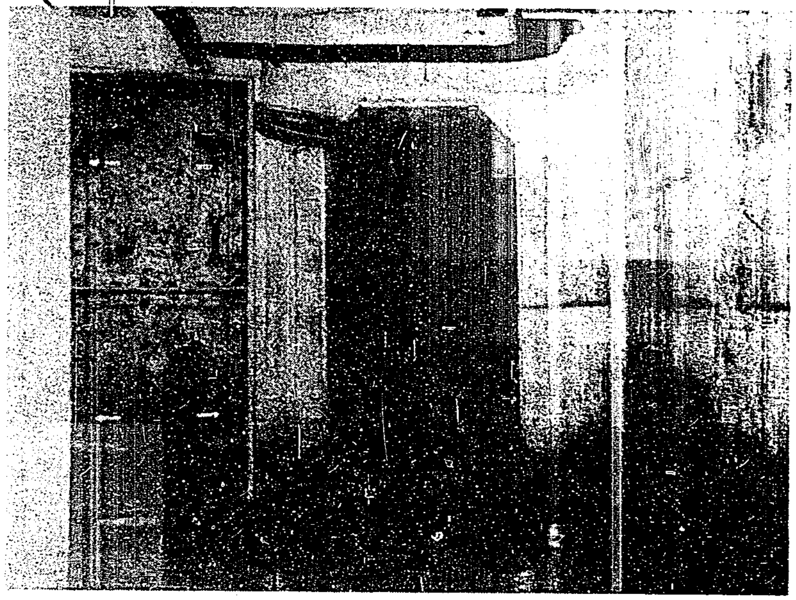


Figure 41

MAIN CORRIDOR, 2nd DECK, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

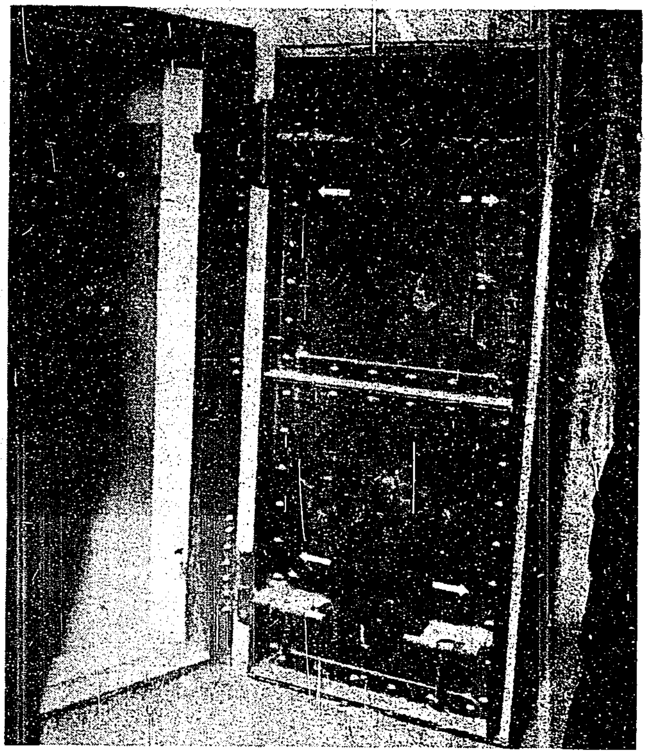


Figure 42

TYPICAL BLAST DOORS FOR MAIN ROOMS, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

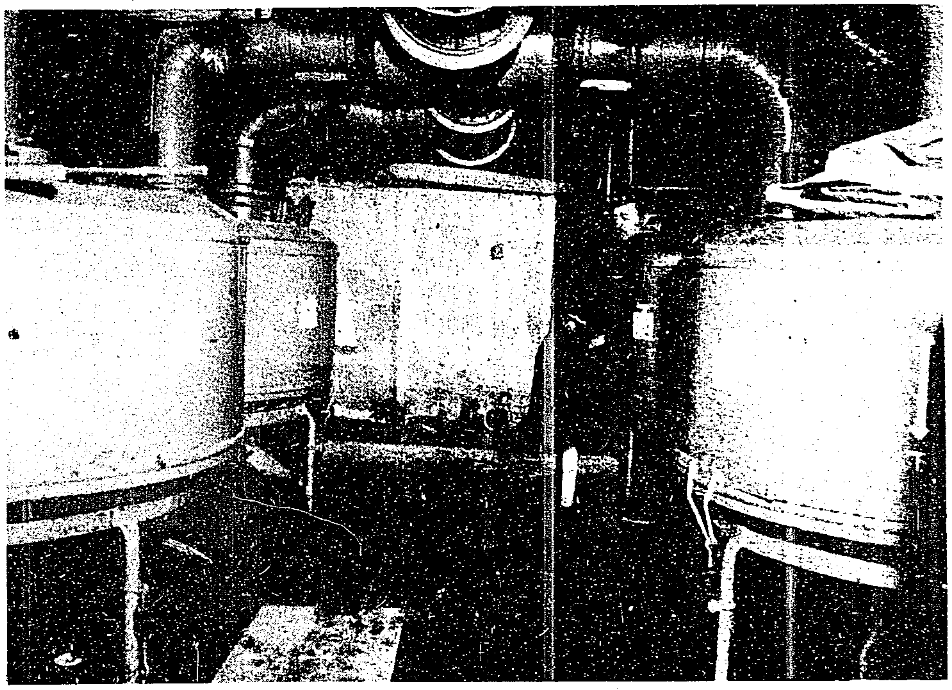


Figure 43
VENTILATING SYSTEM, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

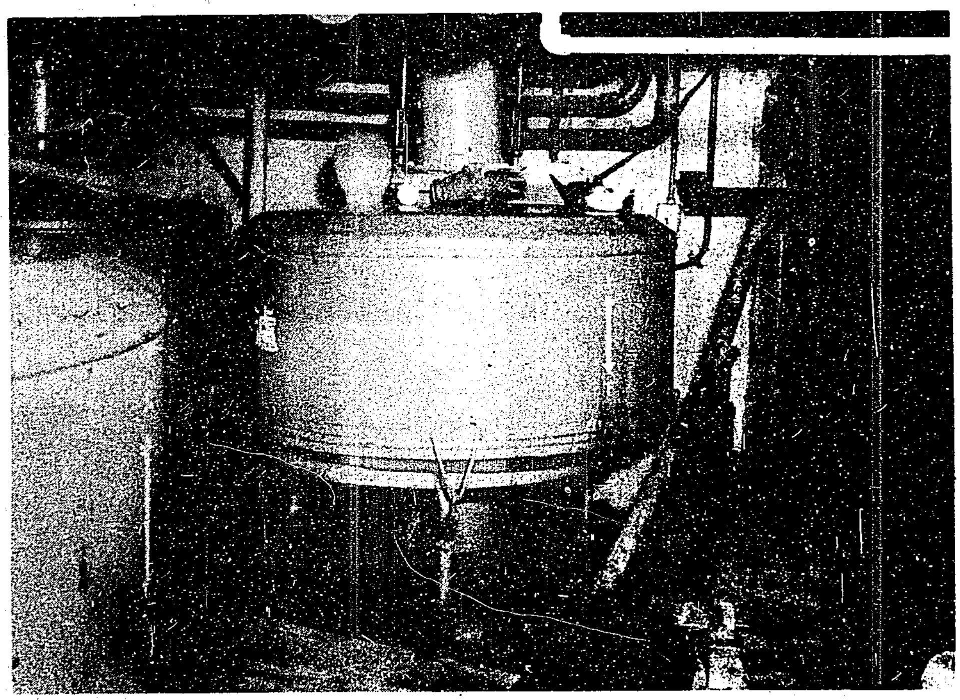


Figure 44
AIR FILTER, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

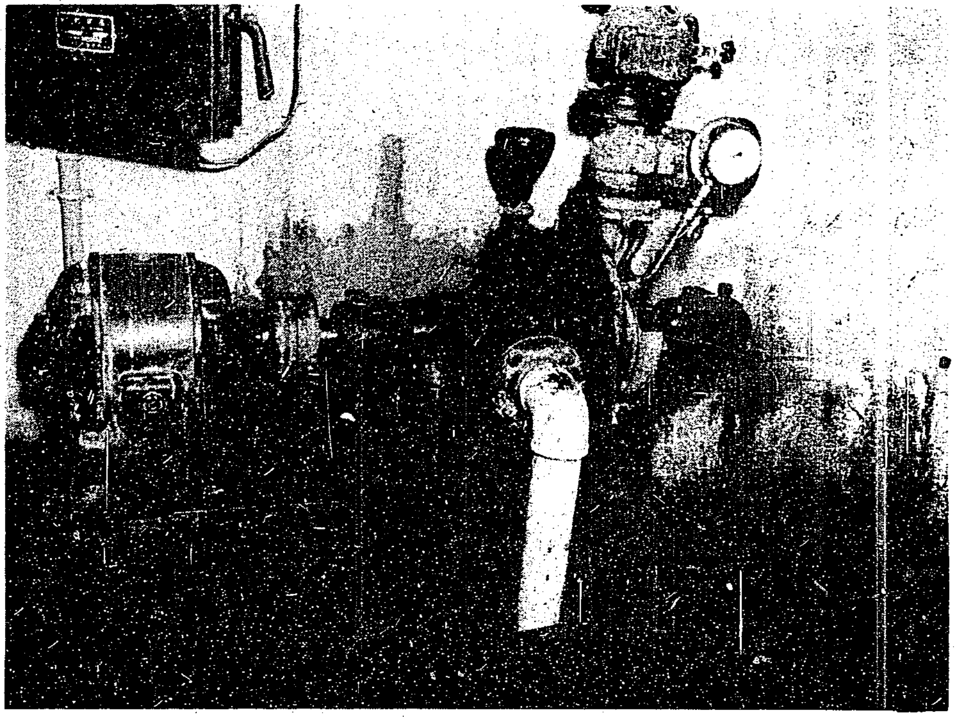


Figure 45
DRAINAGE PUMP NO. 1, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

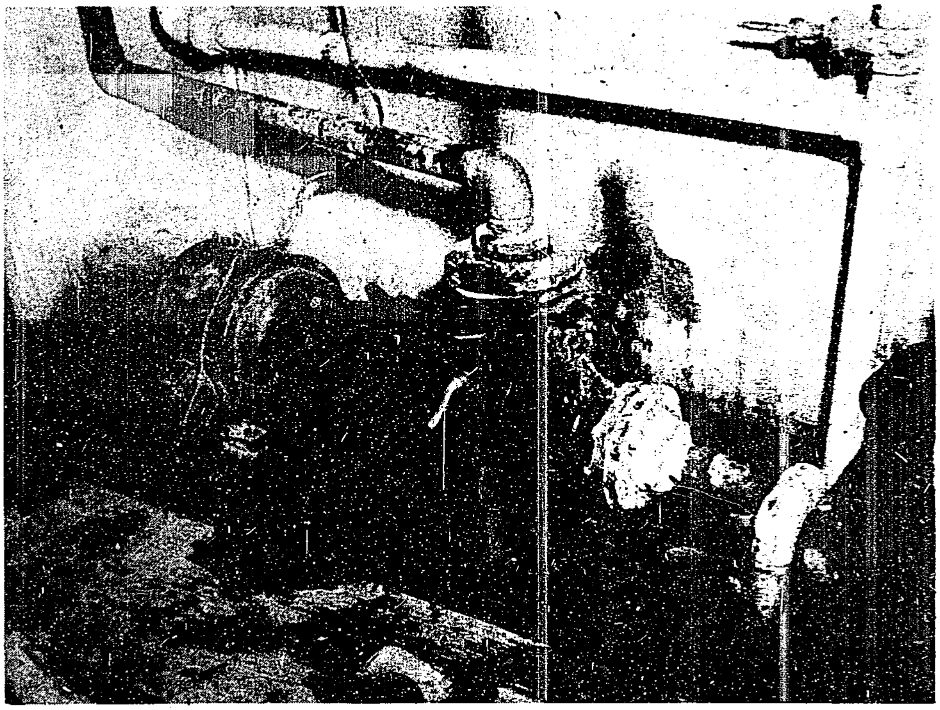


Figure 46
DRAINAGE PUMP NO. 2, UNDERGROUND HEADQUARTERS, JAPANESE NAVY MINISTRY

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED TO THE WASHINGTON DOCUMENT CENTER VIA ATIS

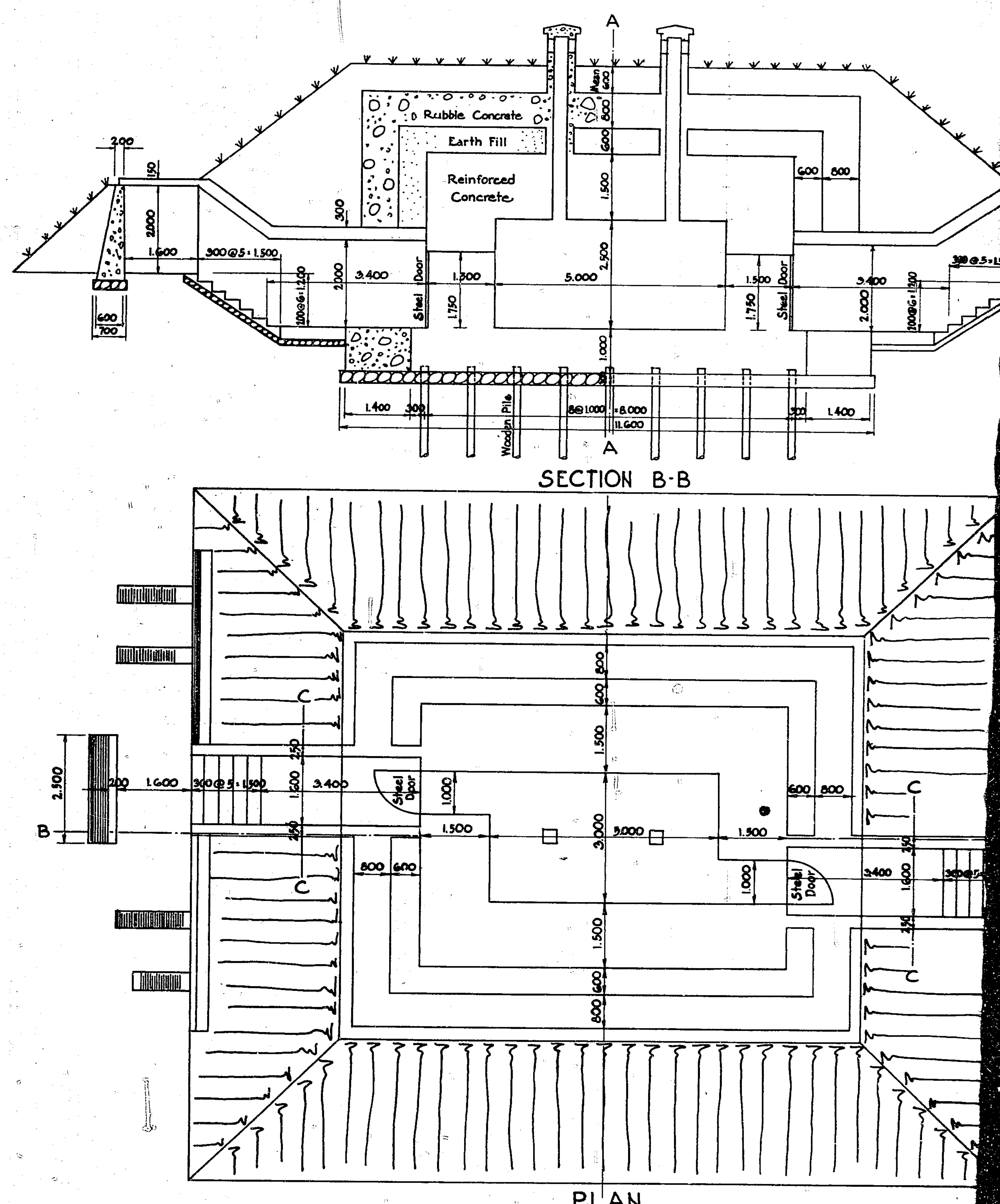
NavTechJap No.	Atis No.	Title
ND50-5220	3842	The vibration of various bodies in various media due to concussion, by Dr. K. MUTO, Kai UMEMURA, and Yoshio SAKAI.
ND50-5221	3843	Theoretical studies on bomb-resistant structures with reference to simple supporting walls, by Dr. K. MUTO, and Kai UMEMURA.
ND50-5222	3844	Theoretical studies on bomb-resistant structures with reference to walls under impact, by Dr. K. MUTO and Kai UMEMURA.
ND50-5223	3845	Theoretical studies on bomb-resistant structures with reference to walls freely supported at both ends, by Dr. K. MUTO and Kai UMEMURA.
ND50-5224	3846	Studies on the concussion-resistant power of reinforced concrete walls, by Dr. K. MUTO and Kai UMEMURA.
ND50-5225	3847	Theoretical studies in regard to reinforced concrete members subjected to great forces, by Dr. K. MUTO and Kai UMEMURA.

Underground Headquarters of the Japanese Naval Ministry

ND50-5228.1	3848	Main caisson, reinforcing steel, sheet No. 2.
ND50-5228.2	3848	Main caisson, reinforcing steel, sheet No. 3.
ND50-5228.3	3848	Main caisson, reinforcing steel, sheet No. 4.
ND50-5228.4	3848	Main caisson, reinforcing steel, interior stairs, sheet No. 5.
ND50-5228.5	3848	Explosion Mat. No. 2, reinforcing steel, sheet No. 6.
ND50-5228.6	3848	Main caisson, reinforcing steel, computation of weights.
ND50-5228.7	3848	Explosion mat, reinforcing steel, computation of weights.
ND50-5228.8	3848	Main caisson, design.
ND50-5229.1	3849	Entrances, general drawing.
ND50-5229.2	3849	Entrance No. 1, reinforcing steel.
ND50-5229.3	3849	Entrance No. 2, reinforcing steel.
ND50-5229.4	3849	Entrance No. 3, reinforcing steel.
ND50-5229.5	3849	Entrance No. 4, reinforcing steel.

ENCLOSURE (A), continued

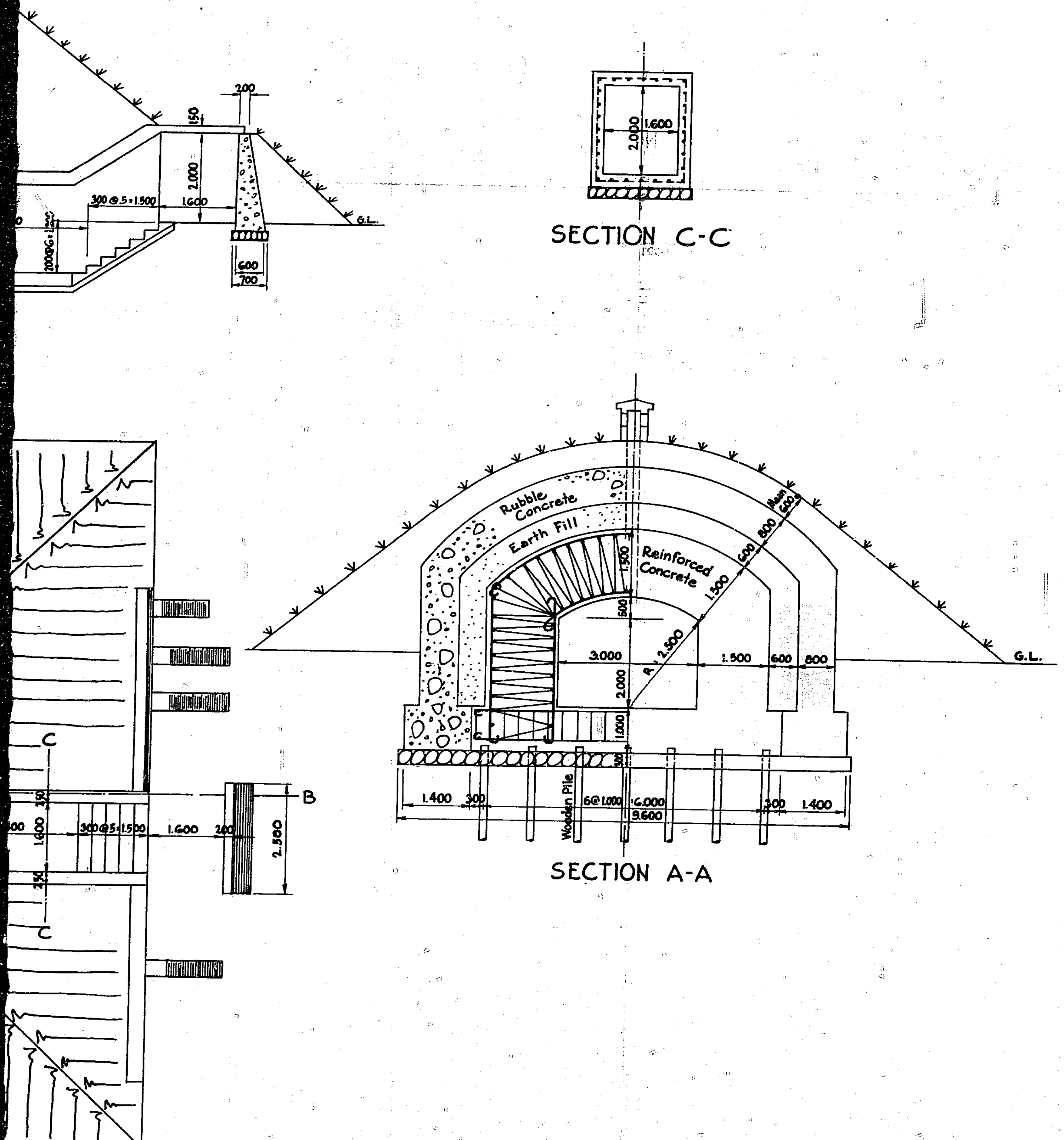
ND50-5229.6	3849	Entrances 1, 2, 3, and 4, reinforcing steel, computation of weights.


Rubble Concrete
Earth Fill
Reinforced Concrete
Steel Door
Wooden Pile
A
C
B
SECTION B-B
PLAN

ENCLOSURE (B)

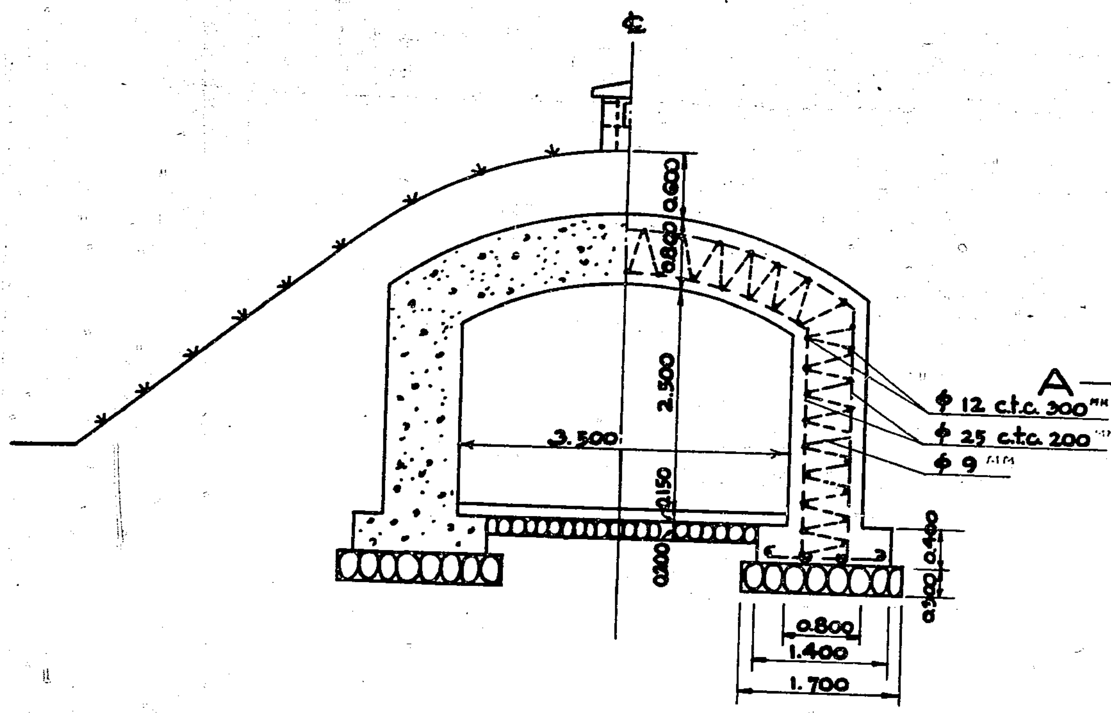
OPERATION FOSSE

Scale 1/50

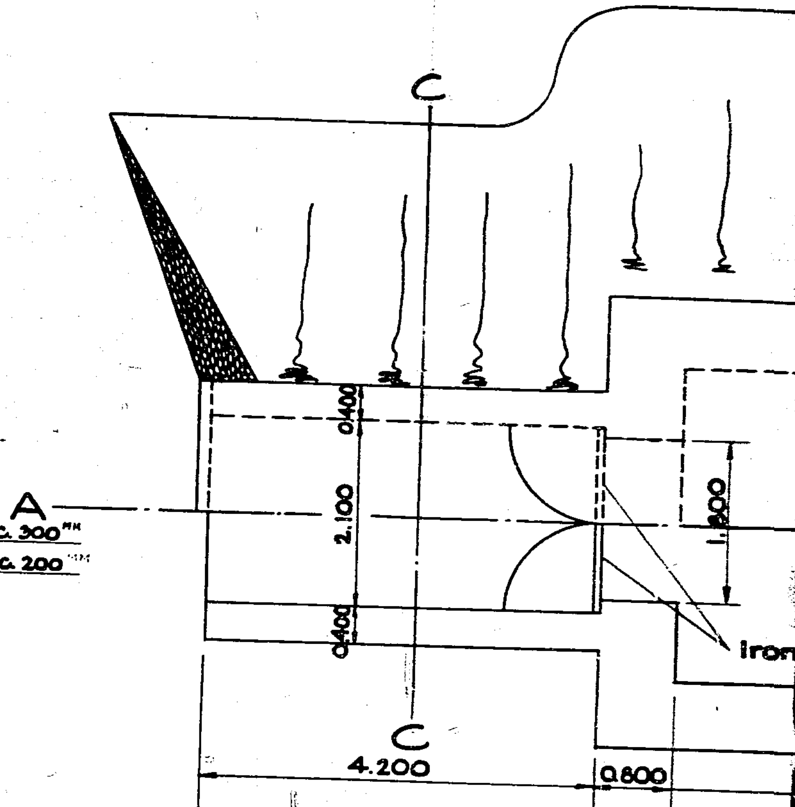


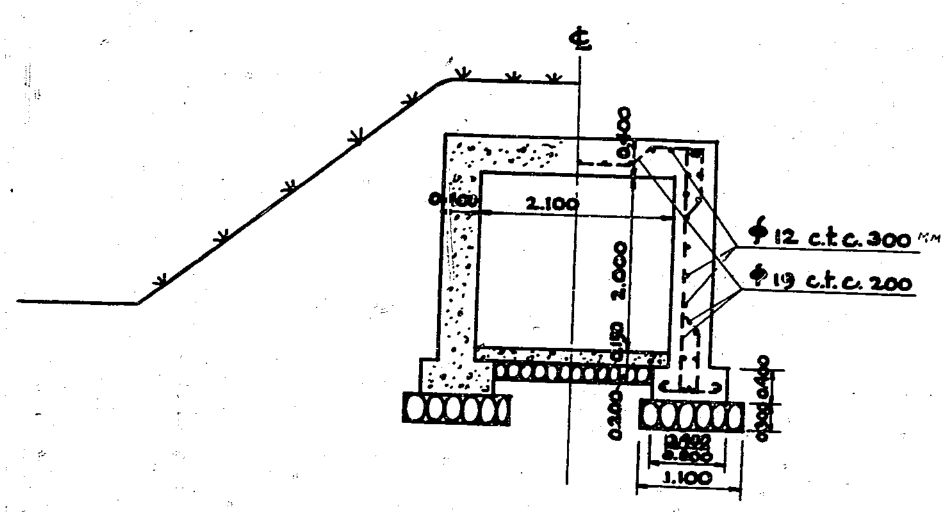
RESTRICTED

ENCL

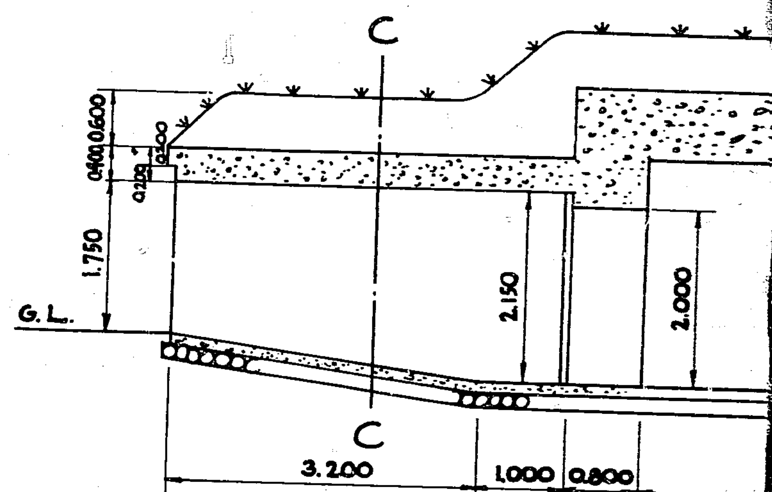


SECTION B-B



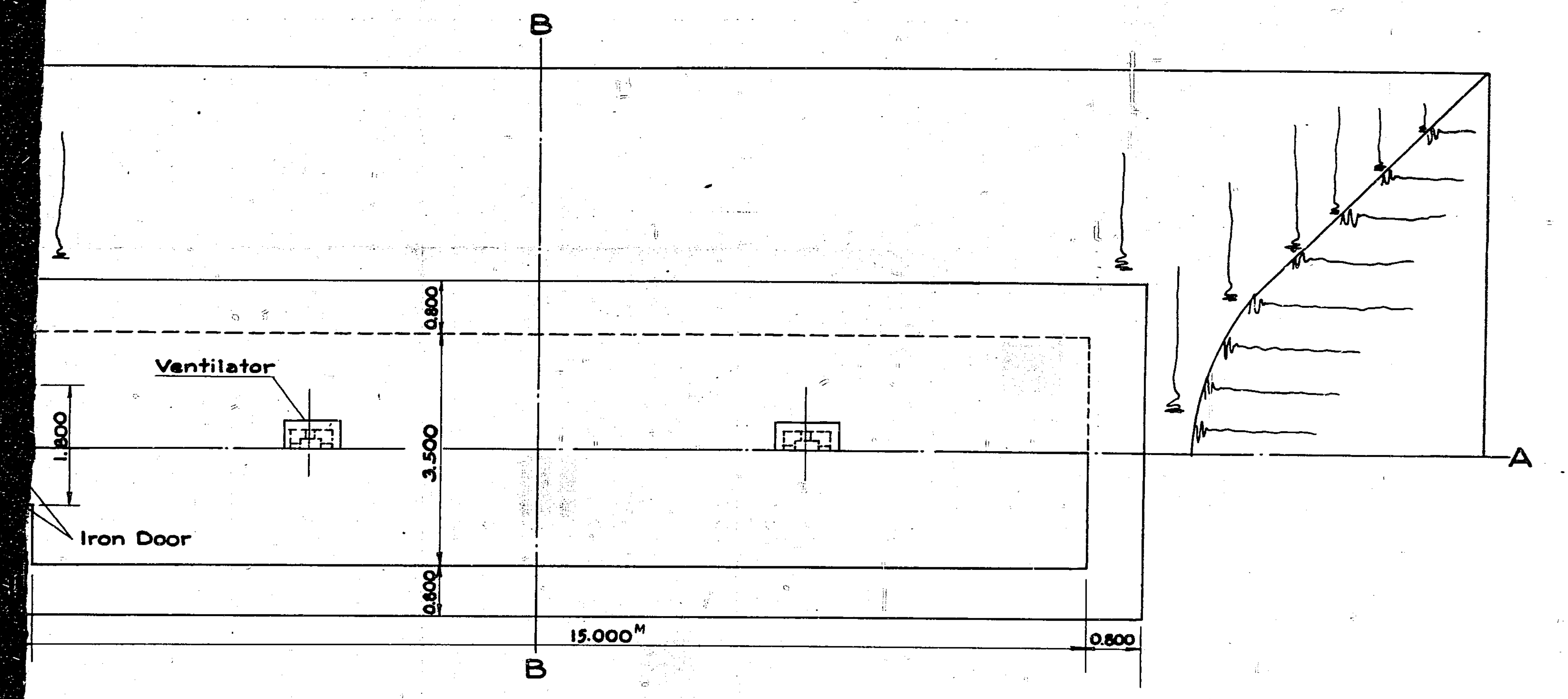


SECTION C-C

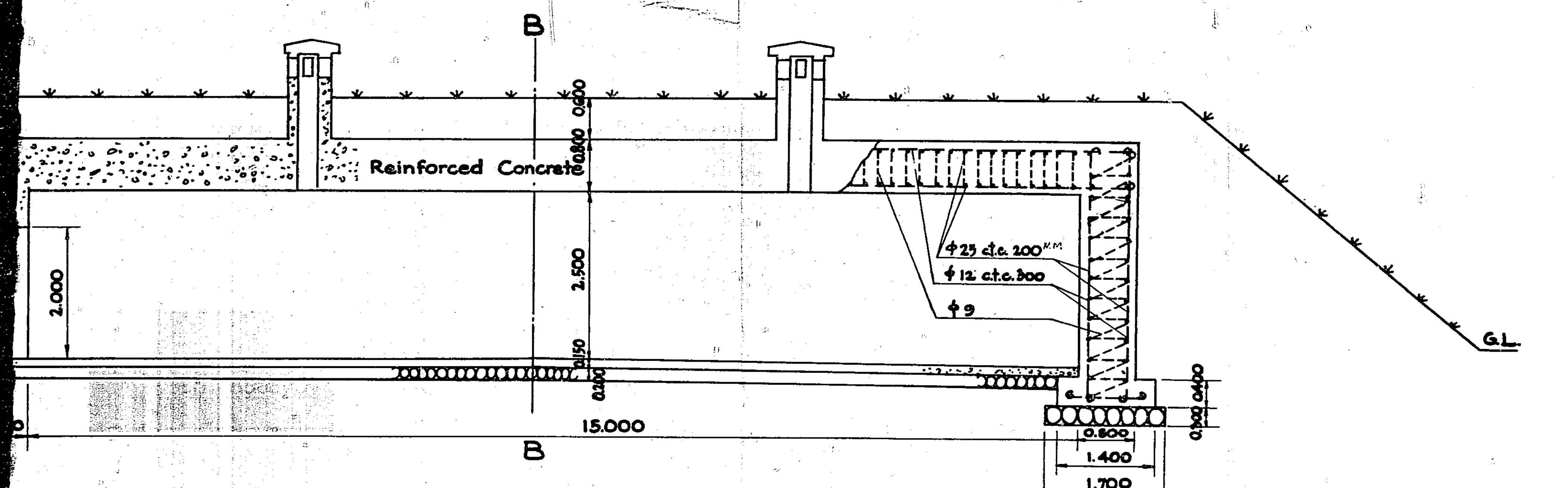


TORPEDO HAN

Sca



PLAN

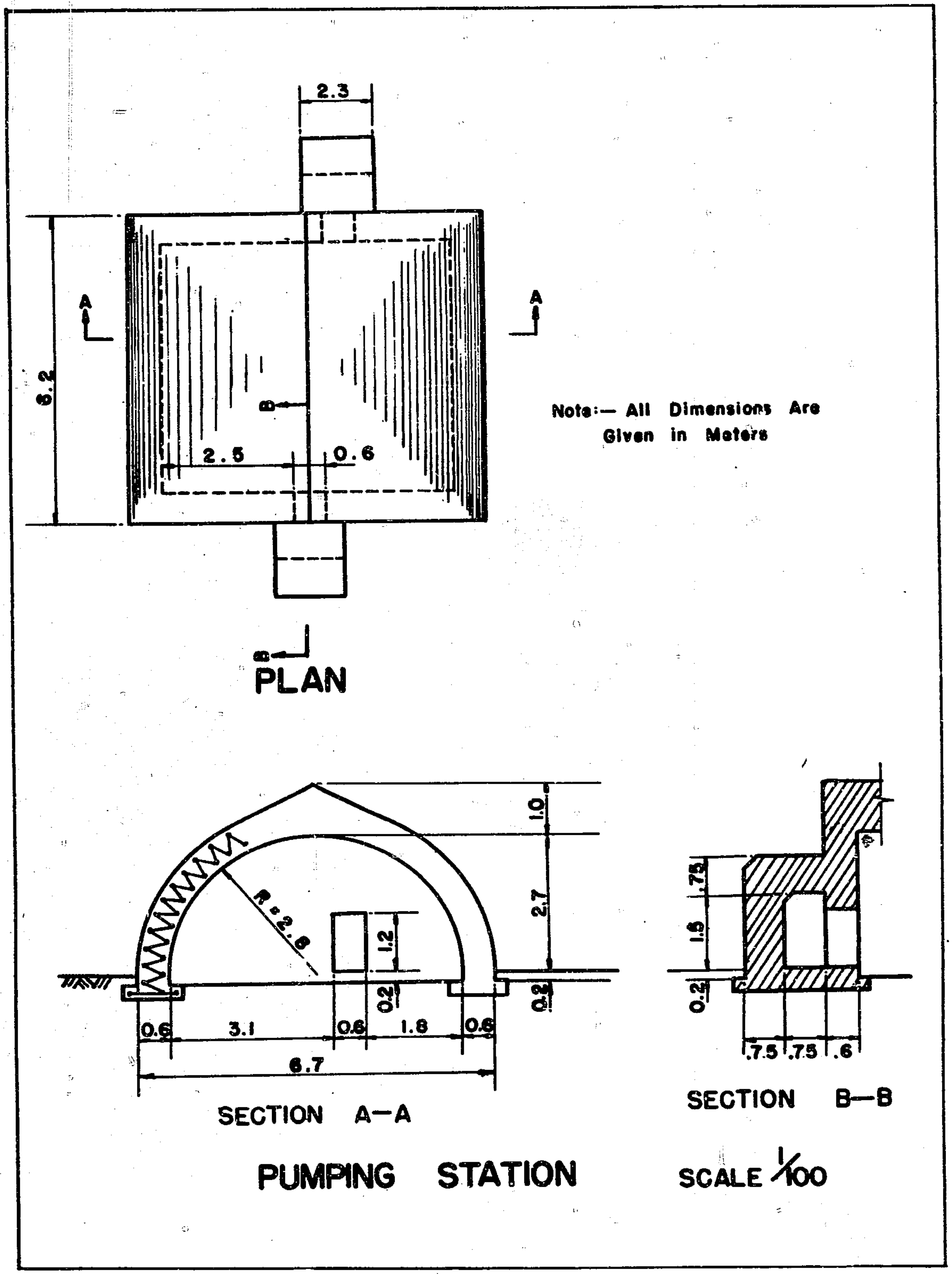


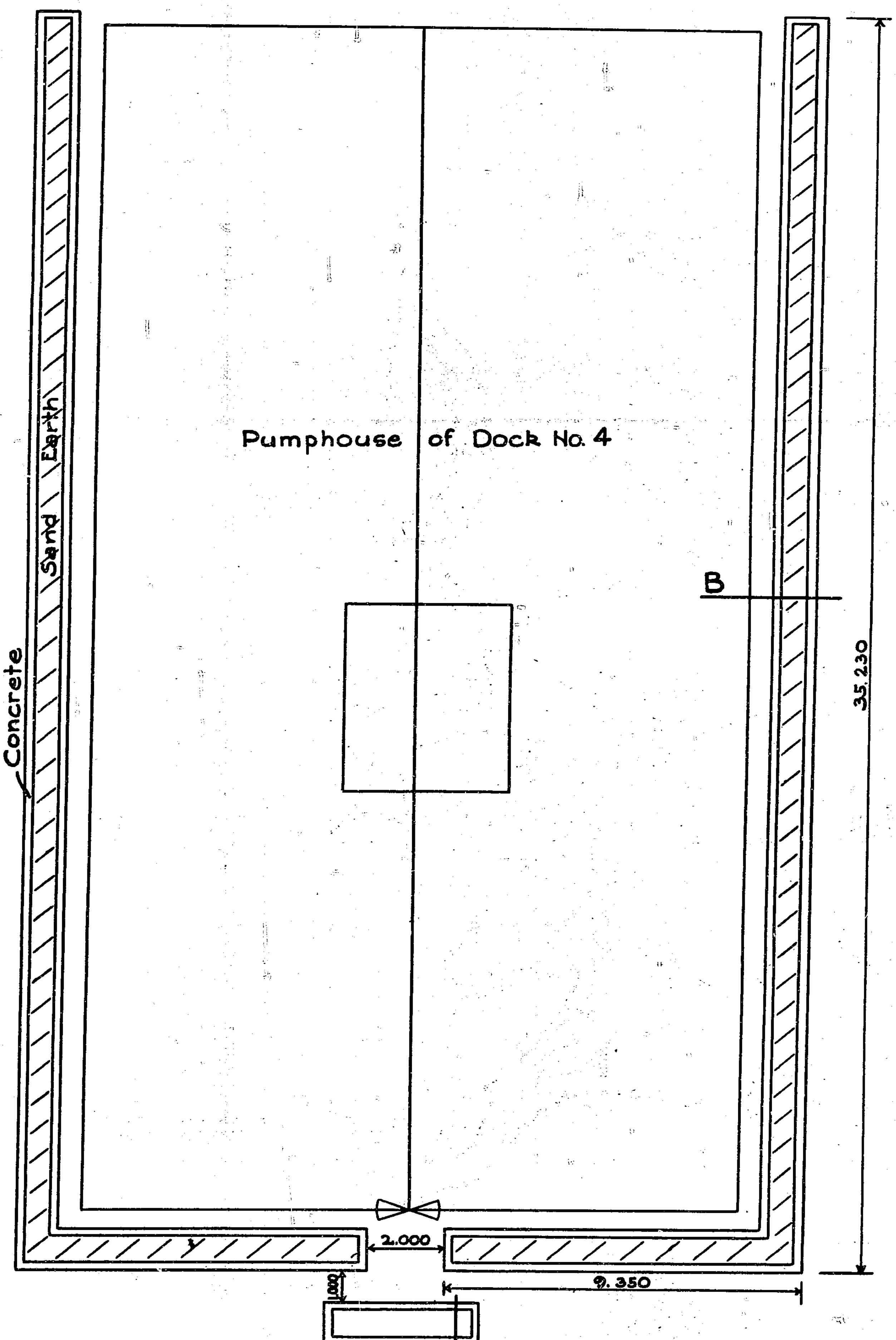
SECTION A-A

HANGAR (FOSSE)

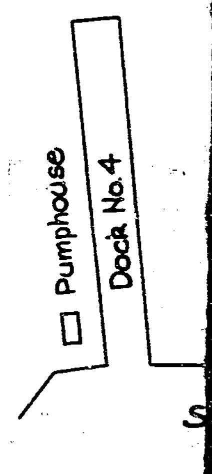
Scale 1/50

ENCLOSURE (F)

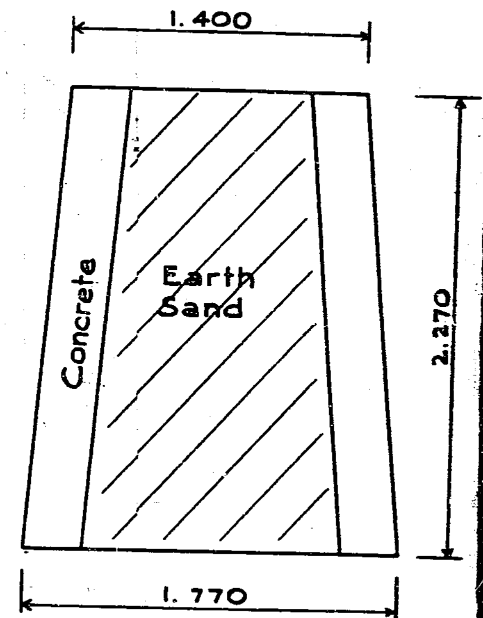

2.3
A
A
6.2
B
2.5
0.6
Note:— All Dimensions Are Given in Meters
B
PLAN
1.0
2.7
R=2.8
1.2
0.2
0.2
0.6
3.1
0.6
1.8
0.6
6.7
SECTION A—A
.75
1.5
0.2
.75
.75
.6
SECTION B—B
PUMPING STATION
SCALE 1/100



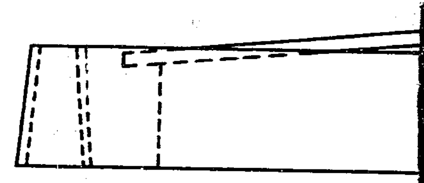
TOP VIEW - PUMPHOUSE
(DOCK NO.4)



SHIPBUILDING D

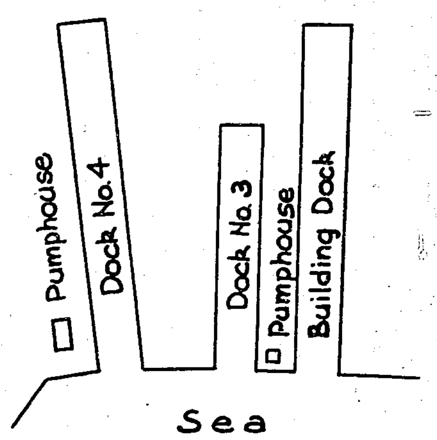


SECTION B
SECTION OF AIR
(FOR PUMPHOUSE

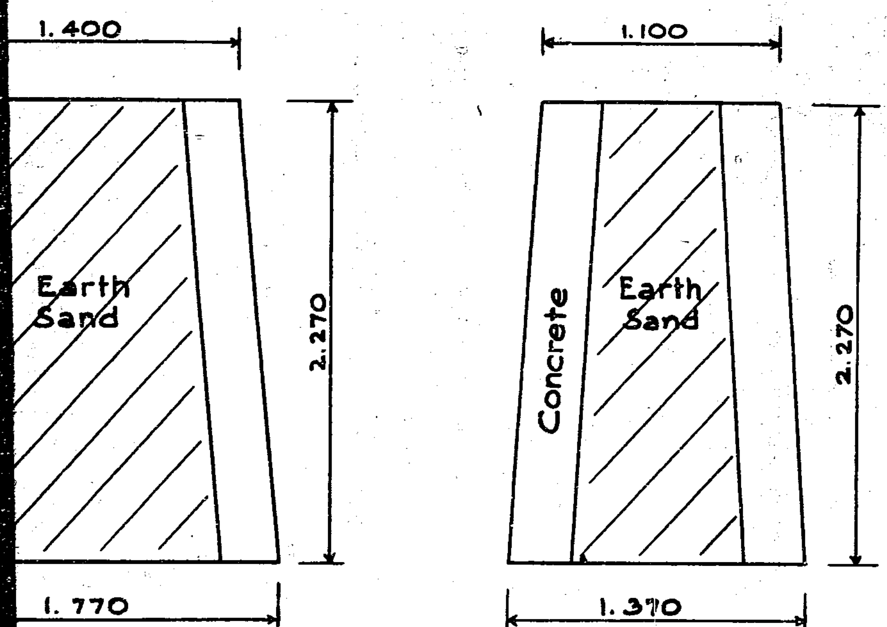


FRONT

CHART OF DETAIL
WALL FOR PUMP
AND DRY
– K



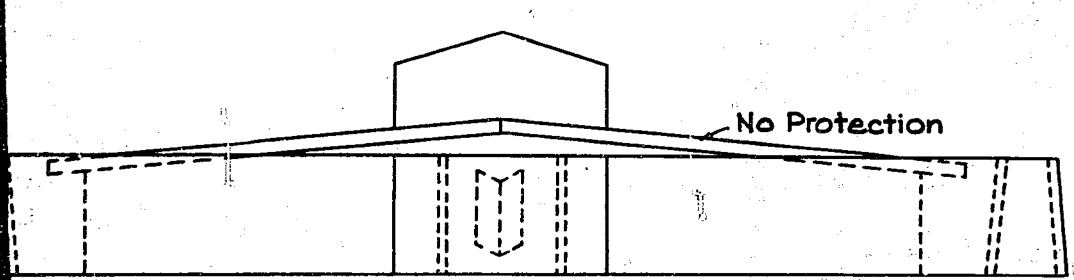
HIPBUILDING DOCK & PUMPHOUSE-DOCK NO.4



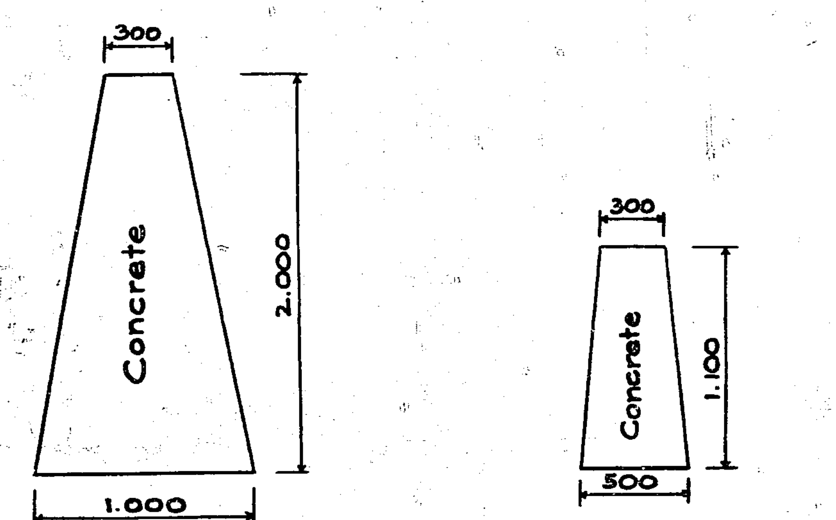
CTION B

SECTION A

CTION OF AIR DEFENSE WALL
FOR PUMPHOUSE DOCK NO.4)

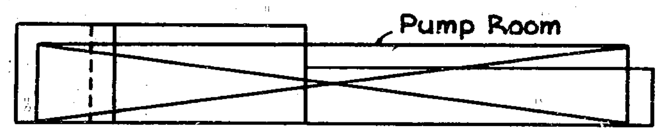


FRONT VIEW - PUMPHOUSE
(DOCK NO.4)

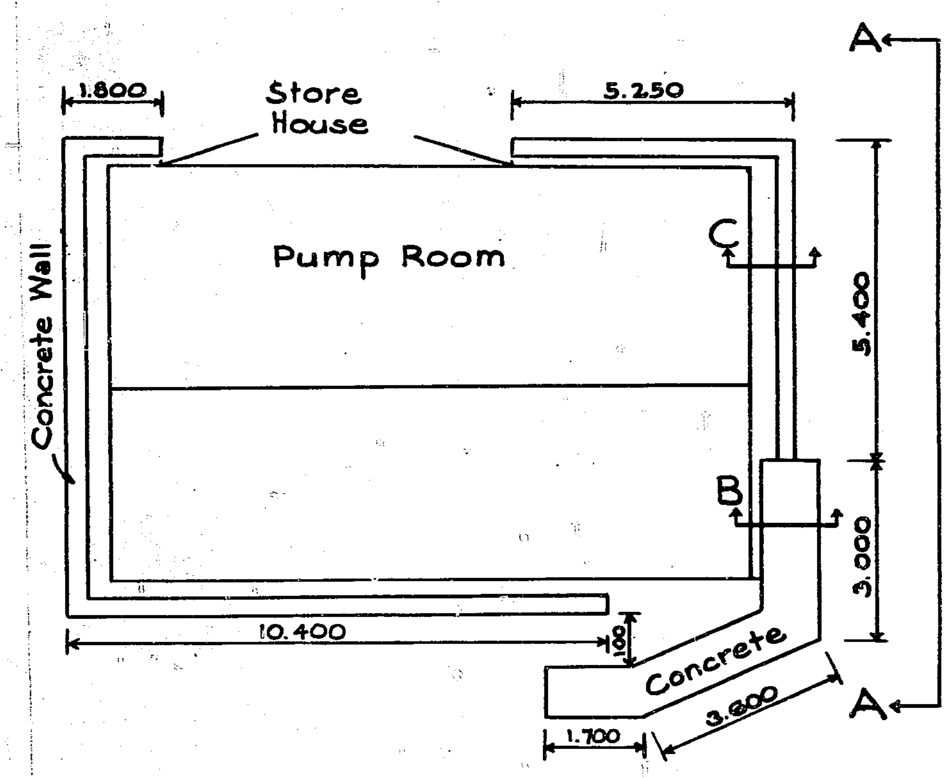


SECTION B SECTION C

SECTION OF AIR DEFENSE WALL 1/25
(USED IN PUMPHOUSE - SHIPBLDG. DOCK)



SIDE VIEW - PUMPHOUSE A-A LINE 1/100
(SHIPBLDG. DOCK)



TOP VIEW - PUMPHOUSE
(SHIPBLDG. DOCK)

OF DETAILED STUDY OF AIR DEFENSE OR PUMP HOUSES OF BUILDING DOCK AND DRY DOCK NO.4
- KURE -

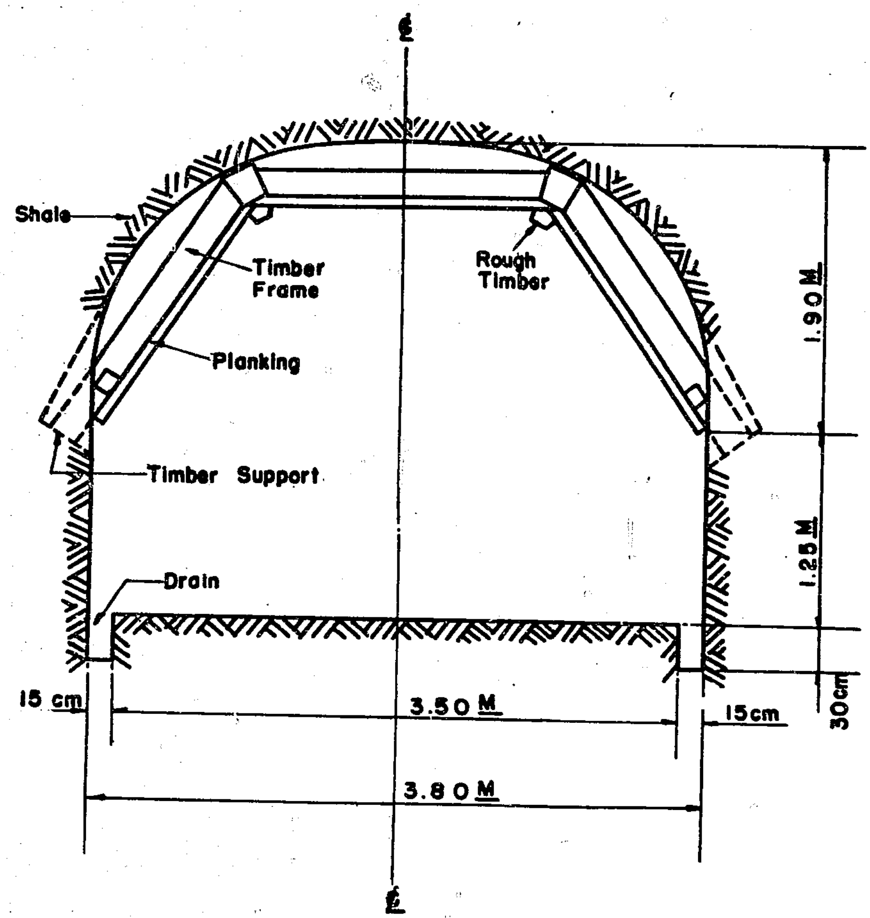
ENCLOSURE (I)

UNDERGROUND INSTALLATIONS FOR AIRCRAFT MANUFACTURING COMPANIES

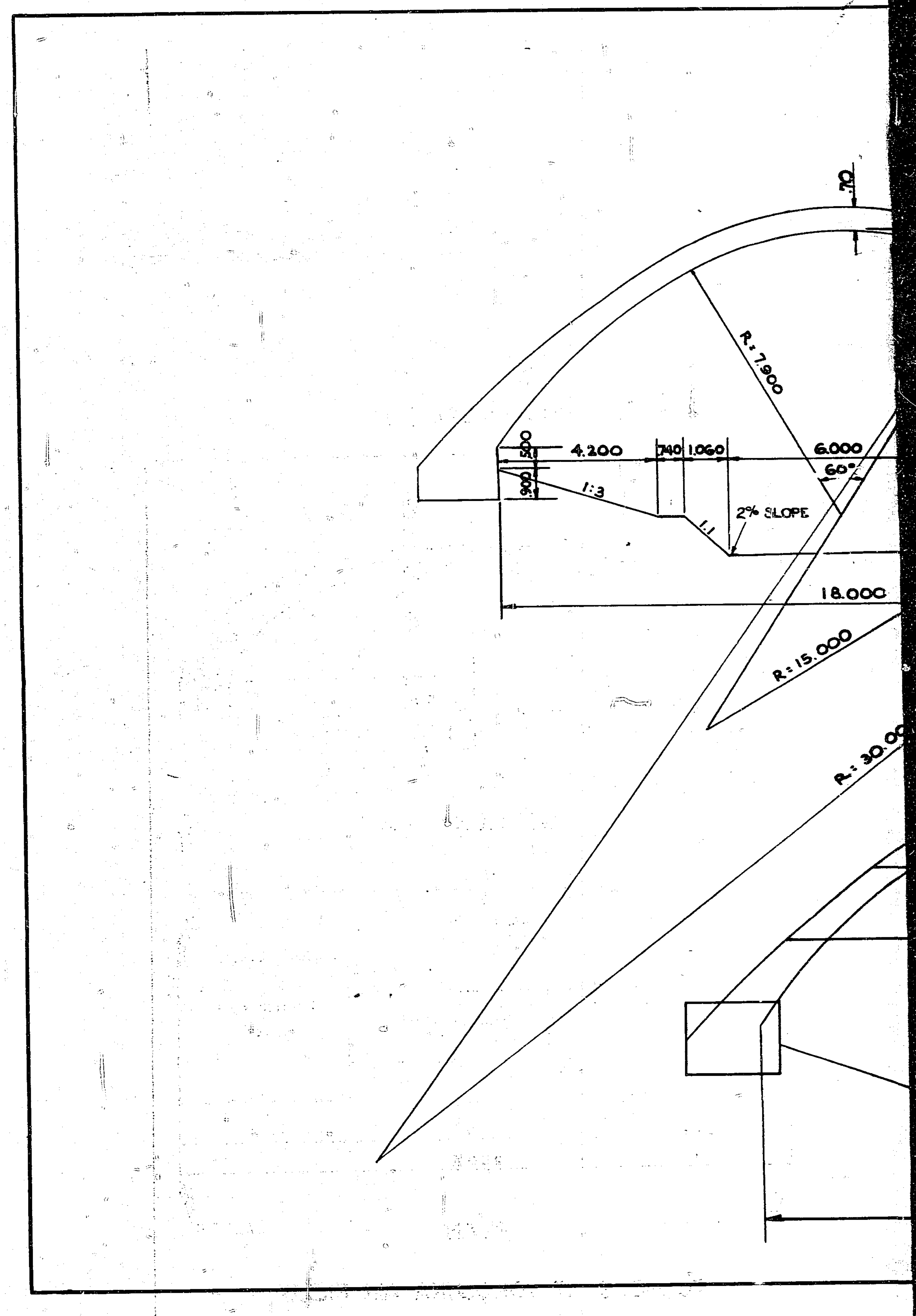
Location	Name of Company	Type	Area (m^2)	Date completed (1945)
Oya	Nakajima (engine)	cave	20,000	May 31
Gokan	Nakajima (body)	tunnel	15,000	August 10
Oami	Hitachi (body)	tunnel	12,000	May 31
Seto	Aichi (body)	tunnel	12,000	May 31
Tsu	Mitsubishi (body)	cave	20,000	May 31
Kurashiki	Mitsubishi (body)	tunnel	10,000	May 31
Kashii	Kyushu (body)	tunnel	10,000	May 31
Fukuchiyama	Kawanishi (body)	tunnel	15,000	June 30
Komatsu	Nakajima (body)	tunnel	10,000	May 31
Fukui	Aichi (engine)	cave	10,000	May 31
Hirono	Sumitomo (propeller)	tunnel	10,000	June 30
Hojo	Kawanishi (body)	tunnel	8,000	July 31
Koyoen	Kawanishi (body)	tunnel	5,000	July 31

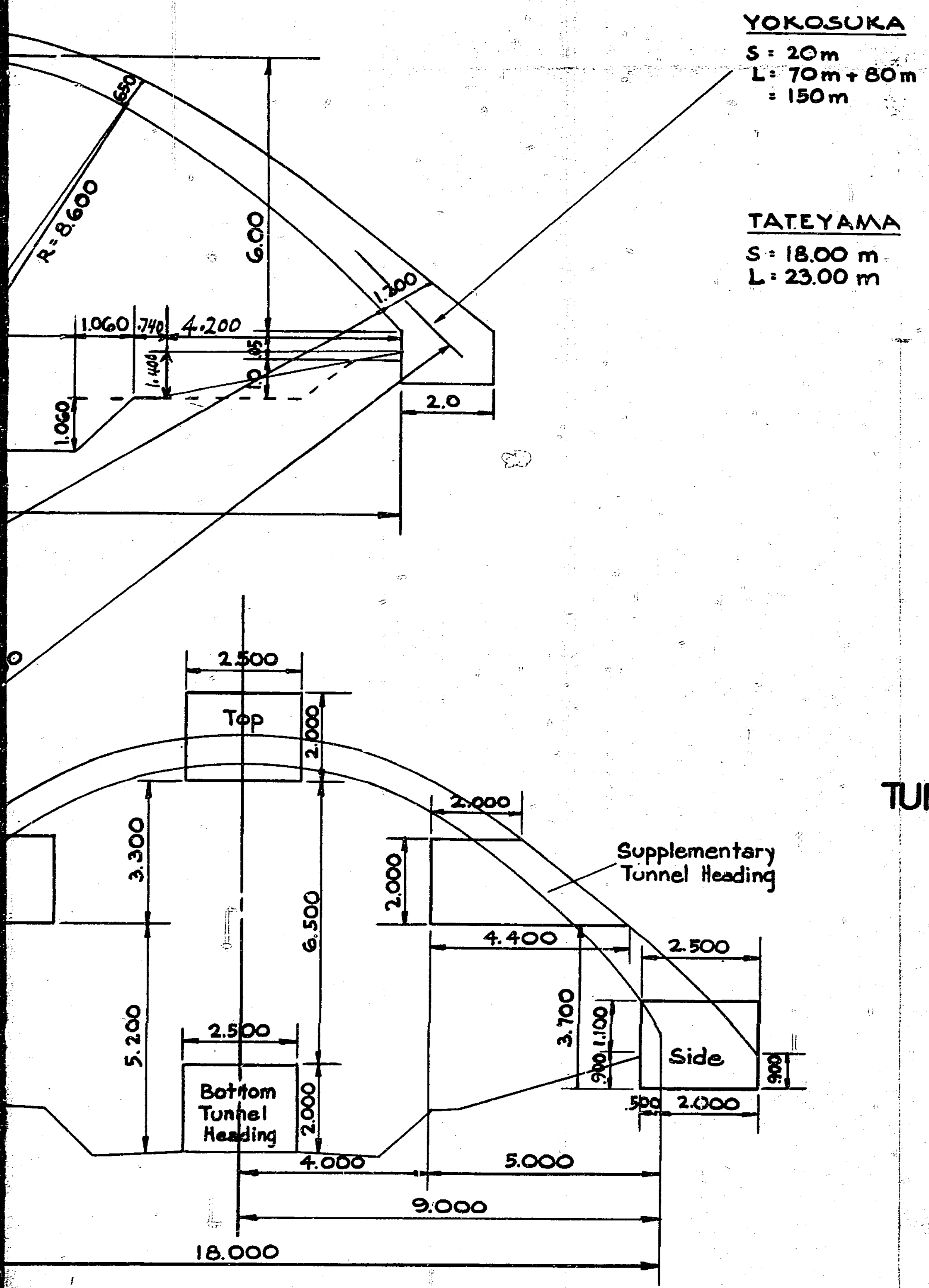
Remarks: There have also been constructed half-underground installations of approximately the same area as those listed herein.

ENCLOSURE (J)



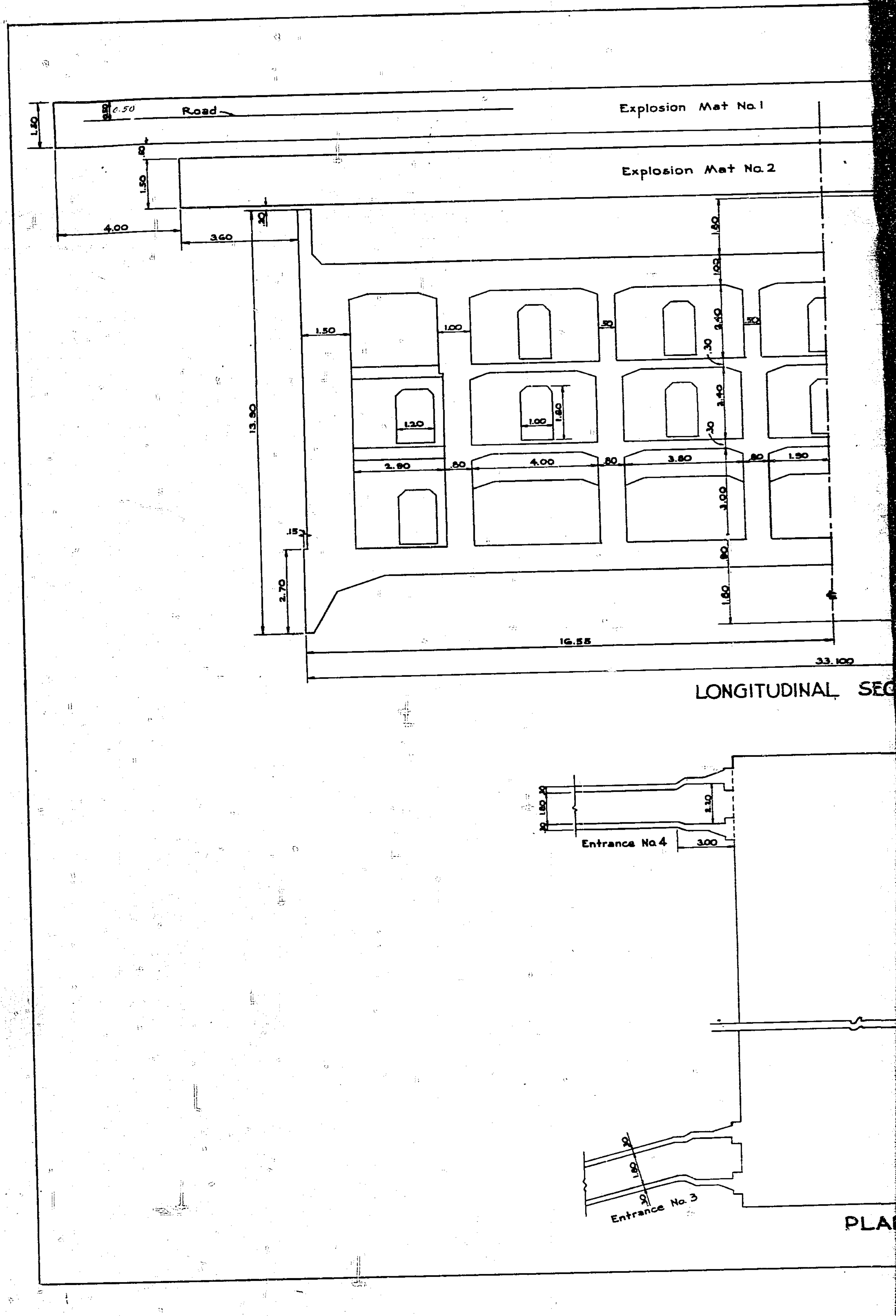
TYPICAL TUNNEL SECTION
HITACHI AIRCRAFT COMPANY AT OAMI


.70
R=7.900
.500
4.200
.740
1.060
6.000
60°
.900
1:3
1:1
2% SLOPE
18.000
R=15.000
R=30.00

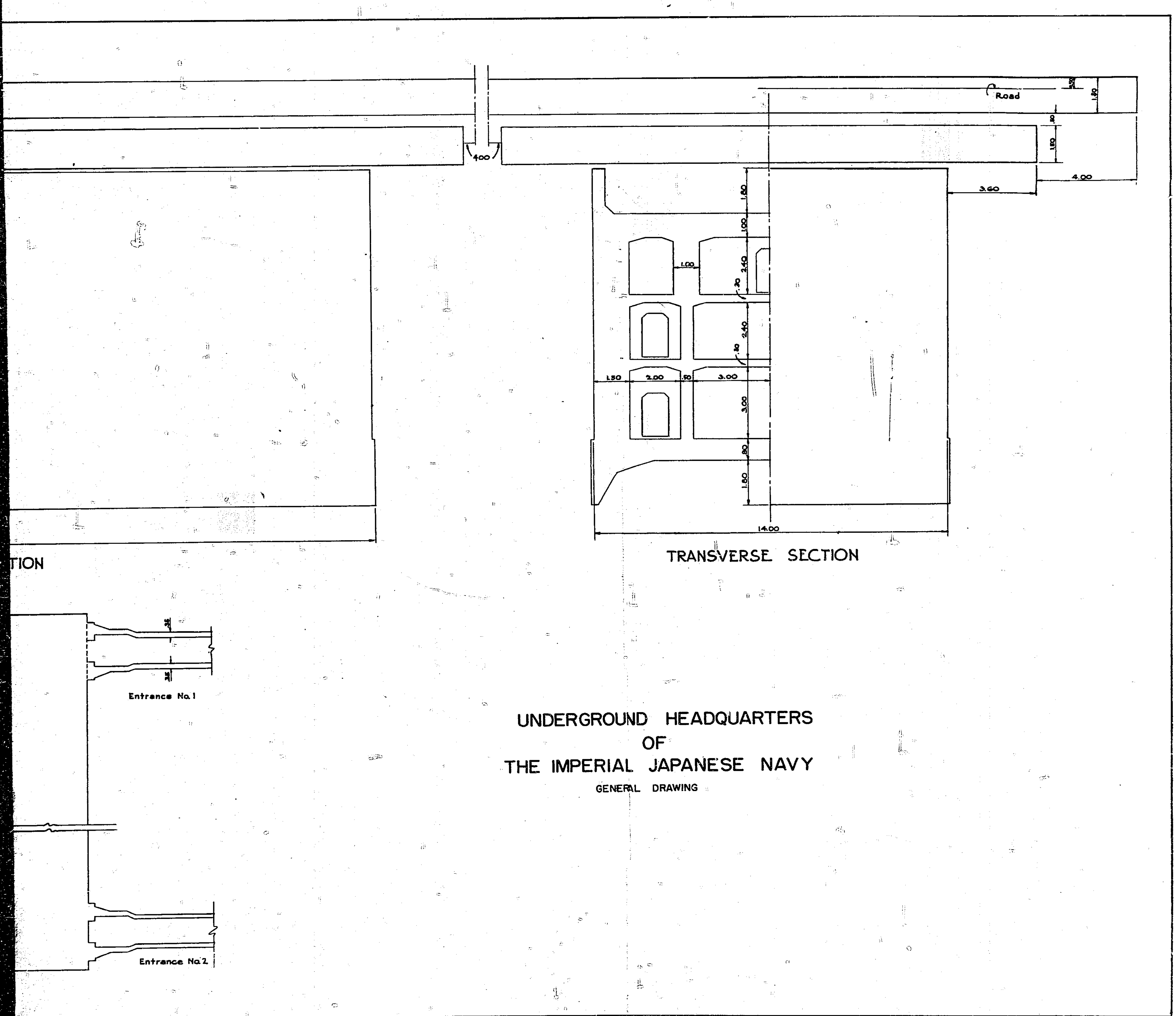


TYPICAL SECTION

TUNNEL REVETMENT AT TATEYAMA AIRFIELD



Road
Explosion Mat No. 1
Explosion Mat No. 2
LONGITUDINAL SEC
Entrance No. 4
Entrance No. 3
PLA


Road
400
4.00
3.60
1.80
1.00
2.40
1.00
.30
2.40
.30
1.50
2.00
.50
3.00
3.00
.80
1.80
14.00
TRANSVERSE SECTION
TION
Entrance No. 1
Entrance No. 2
UNDERGROUND HEADQUARTERS
OF
THE IMPERIAL JAPANESE NAVY
GENERAL DRAWING