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INSPECTION MANUALS FOR MOVABLE BRIDGES

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ABSTRACT

Routine periodic inspections of movable bridges lead to preventative maintenance and various remedial measures. This paper describes inspection manuals that were prepared by the author for a swing bridge and a bascule bridge. Both bridges were orthotropic steel deck plate structures with an asphalt surface. Each manual is about 65 pages in length, and during an inspection observations may be entered directly in the manual so that it also serves as an inspection report.

An introductory portion of these documents includes the following format: (a) general instructions for use of the manual, (b) qualifications of inspectors, (c) inspection rating system, (d) description of bridge, (e) operation of the bridge, and (f) interlocking of control functions. The inspection procedures portion of each manual provides a functional separation of inspection duties as follows: (1) structural inspection, (2) mechanical inspection, (3) electrical and control systems inspection, (4) records inspection and statistical abstract, (5) general operation of span, (6) spare parts inventory, and (7) inspection summary. The substance of each of the above sections is presented, as well as some sample excerpts from the documents.

Annual inspections using these manuals minimize maintenance problems and promote confidence in the continuing integrity of the structures.

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INTRODUCTION

Mechanical portions of a movable bridge often receive frequent attention by the staff associated with the structure, such as lubrication of moving parts which might be done on a monthly basis. At the other extreme a major review might be carried out about every ten years and include features such as quantitative load carrying capacity rating, investigation with a view to replacement of major components, estimating the years of serviceability remaining, and comparison with revised bridge codes. Between these two limits it is beneficial to have a routine periodic inspection, normally annually, by inspectors who are not personnel associated with the routine operation and maintenance of the structure. This paper describes manuals prepared for this type of annual review, and the corresponding inspections have resulted in preventative maintenance and various remedial measures.

The first manual was written for a specific swing bridge. A second manual was later prepared for a specific bascule bridge. Both manuals are identical in format with only the details tailored to the individual structure. The substance of the documents given later herein will be described for the case of the swing bridge.

Both structures are orthotropic steel deck plate bridges with two highway traffic lanes. The steel deck plate serves as the top flange of the longitudinal rib stringers, as the top flange of the floor beams, and also as the top flange of the main girders. Hence the structural system is essentially a single integral member. An asphalt wearing surface is placed on the deck plate and concrete sidewalks are provided. (Anecdotally, it might be mentioned that the first time the bascule bridge was raised, the asphalt slid off. A better system to secure the asphalt was then provided.) The swing bridge has equal arms, each 109 feet in length, and there are four fixed approach spans, two at each end. Figs. 1 to 5 (at the end of the text) show various details. The bascule bridge is a single leaf structure, having a clear span of about 50 feet, and one fixed adjacent span. A hydraulic system is incorporated in the bascule structure, but not in the swing bridge.

Each section of the manuals will be described in substance below with excerpts from the manual for the swing bridge shown indented. A manual is about 65 pages in length, and during an inspection observations may be entered directly on the document so that it also serves as an inspection report.

INTRODUCTORY PORTION OF MANUAL

Sections (a) to (f) described below are for general background and information and require no comment by the inspectors.

(a) General Instructions for the Use of the Manual

This section gives the name of the bridge and the year construction was completed. A specific time of year for this annual inspection is

recommended and it is noted that the work is in addition to inspection by maintenance personnel as described in the *Operating Manuals*.

(b) Qualifications of Inspectors

It is required that the work shall be carried out by or under the direct supervision of a professional engineer and that inspectors not be personnel associated with the routine operation and maintenance of the structure. Familiarity and access to the contract drawings, specifications, shop drawings, and mechanical and electrical manuals should be a prerequisite for inspectors.

(c) Inspection Rating System

The inspector(s) shall rate each individual inspection item according to the following classifications:

Classification	Rating
The item or component is satisfactory with or without minor deficiencies. Deficiencies, if any, are to be noted by the inspector.	A
The item or component is adequate at the time of inspection with significant deficiencies which could cause concern before the next inspection.	B
The item or component has significant deficiencies which require attention or replacement before the next inspection.	C
The inspector's report shall describe fully and comment on any deficiencies which have been observed.	

(d) Description of Bridge

A general description of the structure and primary mechanical and electrical equipment is presented (about two pages). Reference is made to any duplication of components to provide for malfunction.

(e) Operation of the Bridge

A step-by-step procedure for opening and closing the bridge is detailed stating the order to use various buttons and switches. Information is also given on operating in an overtravel zone or using the emergency motors.

(f) Interlocking of Control Functions

The various interlocks which prevent such things as selection of the green navigation signal before the span is fully open are itemized. Any switches which allow bypassing some of the interlock functions under abnormal conditions are also given.

INSPECTION PROCEDURES PORTION OF MANUAL

This is the main body of the manual and is divided into numbered subsections to permit the assignment of inspection duties to different agencies. The inspector assigns a rating to each item or procedure listed and records comments as appropriate. Subsections 1 to 5 serve as a permanent record of the condition of the bridge. Section 6 is a checklist of spare parts which are required to be kept on site. Finally, Section 7 provides for short narrative summaries regarding the various components and for recommended repairs or other action.

(1) Structural Inspection

Many specific items on the superstructure are listed to be rated individually, including such standard things as condition of paint, concrete sidewalks, railings, joints, connections, asphalt, drains, etc. Certain measurements are required as given in the two items quoted below:

Record the horizontal clearance between the swing span and the approach spans at the centreline, with the swing span closed. (See Fig.6).

Clearance at the west end _____ .
 Clearance at the east end _____ .

Compare with anticipated clearance shown on table in Fig. 6.

Record the drop of the swing span at the centreline relative to the approach spans after wedges are withdrawn -(Fig.7). The measurements are to be taken on a cloudy day or at night to eliminate the effects of temperature differentials. The average drop for the two ends should be 1 5/8 inch. Due to balance wheel clearance, the drop at one end will be slightly larger than 1 5/8 inch and slightly less than 1 5/8 inch at the other end. Check for a small clearance under each balance wheel with wedges driven.

Measured dip at west end _____ .
 Measured dip at east end _____ .

Abutments and piers require various observations such as accumulation of debris on the tops of piers, condition of dry pack grout, evidence of cracking, spalling, exposure of reinforcing steel, rust stains, etc.

Fig. 8 shows the dolphins and it is required that the location of the dolphin protection be checked with the span open.

Structural aspects of the control tower are examined and it is also rated for cleanliness.

For this particular structure there is a settlement problem with the approach fills, so provision for elevation readings is included.

Finally, inspection of the submarine cables shown in Fig. 9, along with a general inspection for scour, is specified to be carried out by a diver.

(2) Mechanical Inspection

A typical example from the manual is as follows:

Thrustor Brakes

- a. Observe brake operation for proper gap between wheel and brake shoes (thrustor to operate at approximately one half of full stroke).
- b. Check spring setting (3 1/4 inches between collars).
- c. Check operating condition of linkage and pins.
- d. Check that bottom pivot of the thrustor is free to tilt.

Similarly, for each of the following items a list of required observations is given:

centre pivot
 looping power cables
 main drive motors
 flexible couplings and gear reducer input shaft
 bridge drive gear reducer
 bridge drive shaft and gears
 wedge drive motors
 flexible coupling between wedge drive motors and gear reducer
 disc brake
 wedge drive gear reducer
 wedge drive shaft
 centering device and limit switch
 roller path
 live load bearings
 auxiliary drives: limit switches
 inspection platform drive mechanism
 traffic gates
 diesel generator
 control tower

The intent of the above list is only to indicate the scope of the work. For each of the items there would be anywhere from one to ten specific observations to be made. For many of the components it is required that the lubrication should be checked, but the manual states that this may be done visually or by reference to the maintenance logs or the operating personnel. Similarly, a visual check is normally considered adequate for tightness of bolts.

(3) Electrical and Control Systems Inspection

The following items are rated in the electrical inspection:

A.C. generator--control tower
 swing bridge controller--control tower
 operator's control desk--control tower
 traffic control gates
 lighting systems
 electrical equipment on swing span
 terminal and junction boxes
 check that indicating lamps are ON for the interlock bypass
 switches at the operator's control desk
 miscellaneous electrical services in control tower
 operation of siren
 bulb replacement

The manual is less specific in general for the electrical work than for the structural and mechanical. An exception is the lighting systems where all lights are specifically mentioned, including nine roadway lights, six passage lights, four dolphin lights, four navigation lights, and four traffic lights.

(4) Records Inspection and Statistical Abstract

A list of all reference documents which should be available at the site such as manuals and drawings is given and the inspector must check that they are there. In addition, the inspector lists miscellaneous other documents or records available on the site. The remaining portion of this rather brief section is quoted below:

Data from Site Records

The following information is to be abstracted from site records for the time period since the last inspection. Records of b. to e. should be kept on site. Items f. and g. may be obtained from interviews.

- a. Date of last inspection _____ .
- b. Total number of swing span openings _____ .
- c. Number of vessels of sufficient height
to require opening the bridge _____ .
- d. Number of commercial vehicles _____ .
- e. Description of repairs, reconstruction or nonstandard
maintenance work per-formed since the previous
inspection.
- f. Summary of unusual service conditions--i.e., due to
weather, malfunction, shutdown for maintenance or
repair, major damage, unusual loads, etc.

- g. List of personnel employed for the bridge operation and maintenance.

RATING

- h. Evaluate their availability and adequacy of data a. to g.

REMARKS:

(5) General Operation of Swing Structure

This section is also quite brief and is quoted in full:

RATING

- 5.1 Observe swing span in operation. Note any unusually operating difficulties-- Record approximate times for wedge operations and swing operations.

- a. Opening to the normal position.
Time to withdraw wedges _____
sec.

Time for opening to the normal
open position _____ sec.
(Design time 137 seconds.)

REMARKS:

- b. Opening in the overtravel zone.
Time for opening _____ sec.
All span movement in this zone
should be done slowly and with
caution.

REMARKS:

- c. Closing in the overtravel zone.
Time for closing _____ sec.

REMARKS:

- d. Closing from the normal open
position. Time for closing
_____ sec. (Design time 137
seconds.)

Time to drive wedges _____ sec.
(Design time 21 seconds.)

REMARKS:

- 5.2 Interview operating and maintenance personnel to determine any problems associated with the project.

REMARKS:

- 5.3 Comment on the ability of the personnel employed for the bridge operation and maintenance to perform their functions. (This question should be discussed with inspectors responsible for other sections of this report.)

REMARKS:

(6) Spare Parts Inventory

A steel storage cabinet for electrical spares, hand tools, etc. is in the control tower. Required tools, lubrication equipment, miscellaneous components, and electrical spares are listed. For each item the quantity that should be available on site is given and the inspector must list the actual quantity on hand. In addition, any tool or other item in poor condition or in need of replacement is to be noted.

(7) Inspection Summary

For the structural, mechanical and electrical inspections the general condition and behaviour of the systems and components is summarized and the total number of items for each rating classification is recorded. Further, the inspector summarizes remedial work according to priority and estimates costs.

With respect to the records inspection and statistical abstract section, the general adequacy of records kept by operating personnel is to be noted and a summary of remedial measures and costs, if applicable, must be given. Further, if appropriate, the inspector is to comment on the information contained in the data obtained from field records.

Relevant summaries, remedial measures, and costs for Sections (5) and (6), General Operation of Swing Structure and Spare Parts Inventory, are to be prepared.

Finally, it is required that the agency, inspecting personnel, and dates of inspection be recorded for the various portions of work.

DISCUSSION AND CONCLUSIONS

Between the ongoing inspection and maintenance by the operating staff and a major review perhaps every ten years, it is believed that an annual general inspection of movable bridges is desirable. This paper presents a suitable format for a manual for such annual inspections. The description of individual components must, of course, be tailored to the particular structure. Annual inspections using these manuals

minimize problems by contributing to the practice of keeping all parts of the structure in good shape and promote confidence in the continuing integrity of the bridges.

SCHEMATIC PLAN OF STRUCTURE

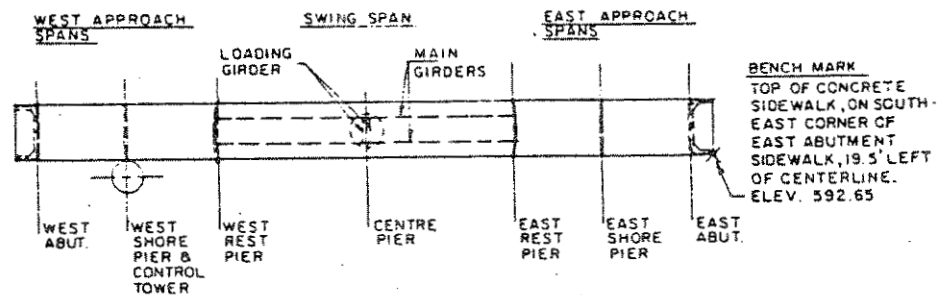


FIG. 1.

SCHEMATIC PLAN OF REST PIER

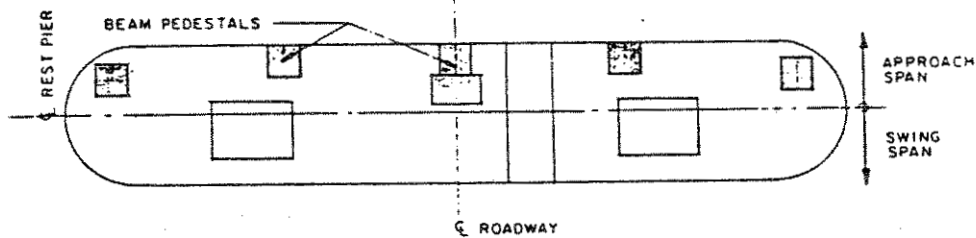


FIG. 2.

SCHEMATIC PLAN OF CENTRE PIER

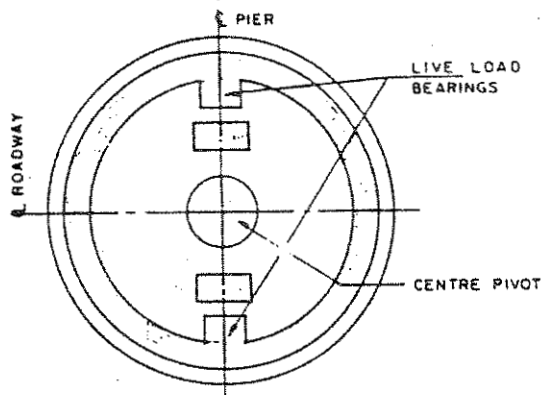


FIG. 3.

APPROACH SPAN CROSS - SECTION

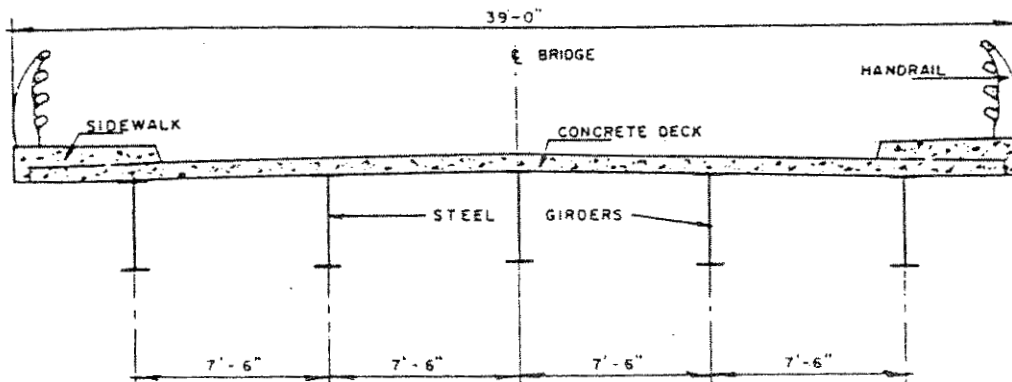


FIG. 4.

SWING SPAN CROSS - SECTION

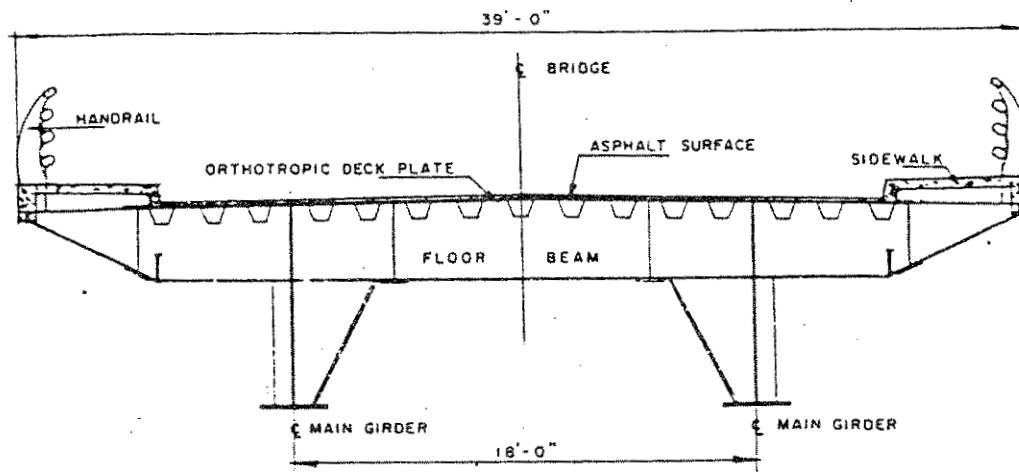


FIG. 5.

CLEARANCE

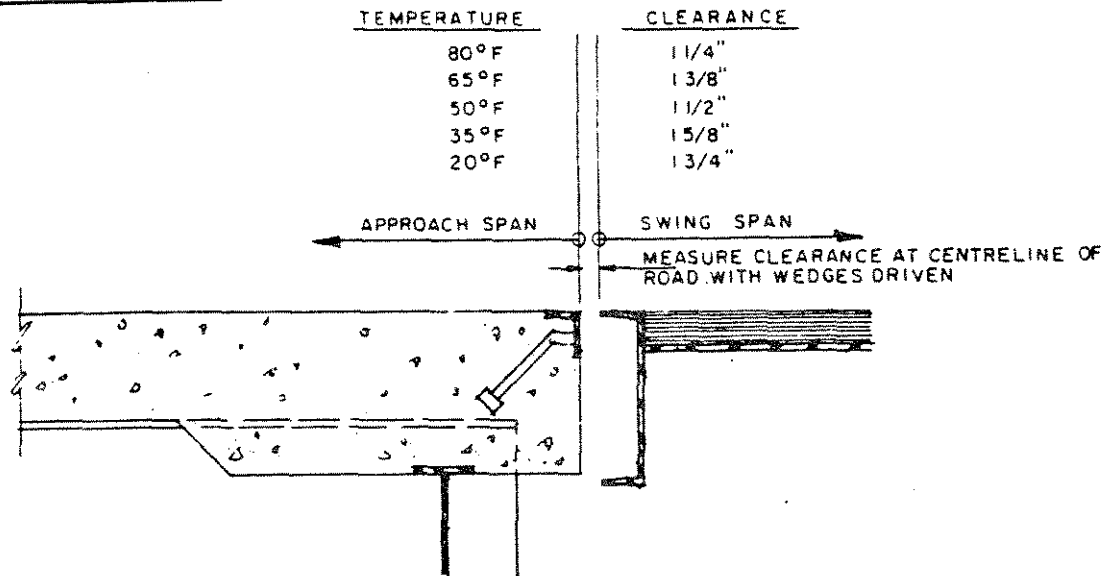


FIG. 6.

WEDGES WITHDRAWN

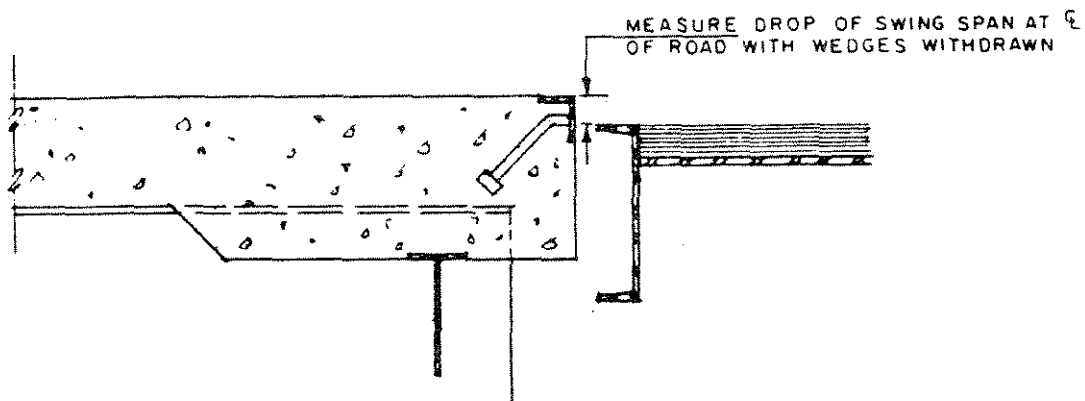


FIG. 7.

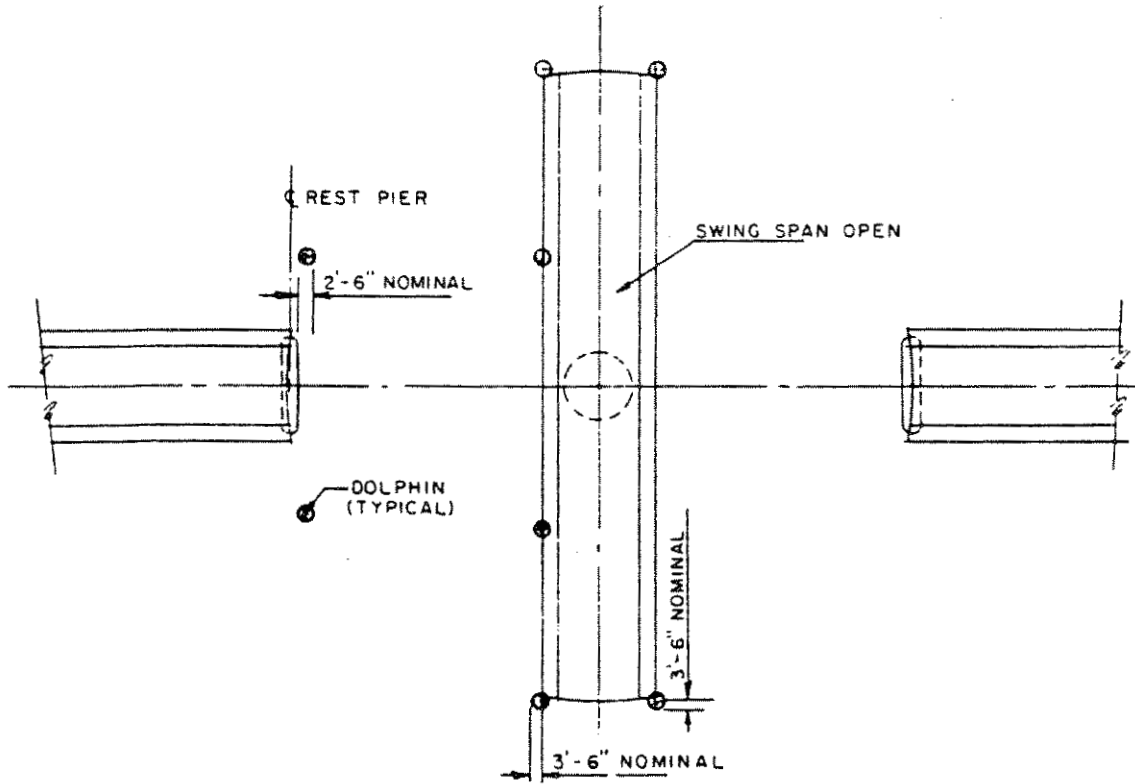
DOLPHINS

FIG. 8.

SUBMARINE CABLES

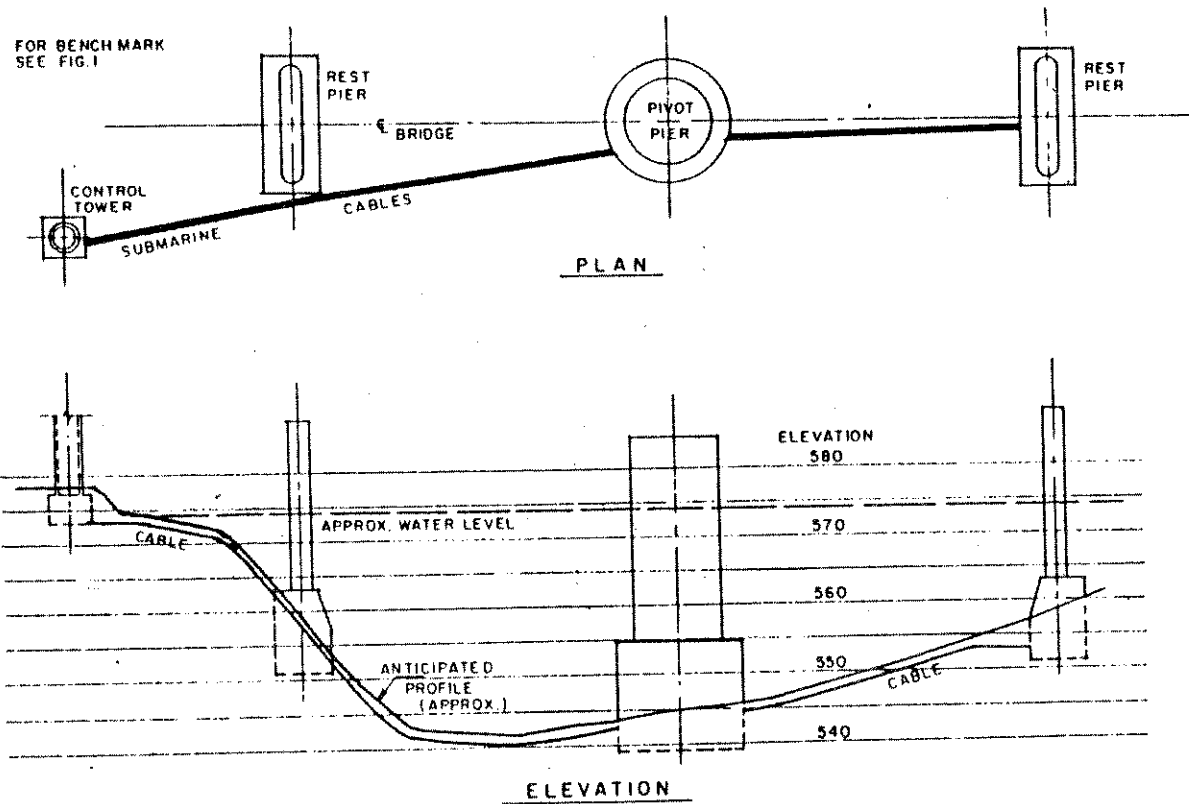


FIG. 9.