Environment Canada / Environnement Canada

CANADA CENTRE FOR INLAND WATERS

CENTRE CANADIEN DES EAUX INTERIEURES

ENGINEERING FEASIBILITY REPORT WITH A FINAL PROPOSAL FOR AN OFFSHORE RESEARCH PLATFORM (ORP)

UNPUBLISHED REPORT ES-506

W. Gibson

UNPUBLISHED REPORT
RAPPORT NON PUBLIE

ENGINEERING FEASIBILITY REPORT
WITH A FINAL PROPOSAL
FOR AN
OFFSHORE RESEARCH PLATFORM (ORP)

UNPUBLISHED REPORT ES-506

W. Gibson

W. Gibson, P.Eng.,
Engineering Services Section
Canada Centre for Inland Waters.
April, 1975

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1: INTRODUCTION

Much concern regarding instrument support towers has developed since two Millard towers collapsed in Lake Ontario under high load storm conditions during November, 1973. Loss of expensive equipment and instrumentation and a sudden end to several scientific programs resulted. (See Fig. 1)

Investigation into the types of support structures used for instrumented studies in the lakes, considering the scientific data return from these and future programs, was carried out by the Mechanical Engineering and Technical Operations Sections. This report and subsequent proposal is the outcome of this investigation, which includes a cost analysis summary of various tower structures and the resulting recommendations.

Fig. 1 - An Overloaded Millard Tower

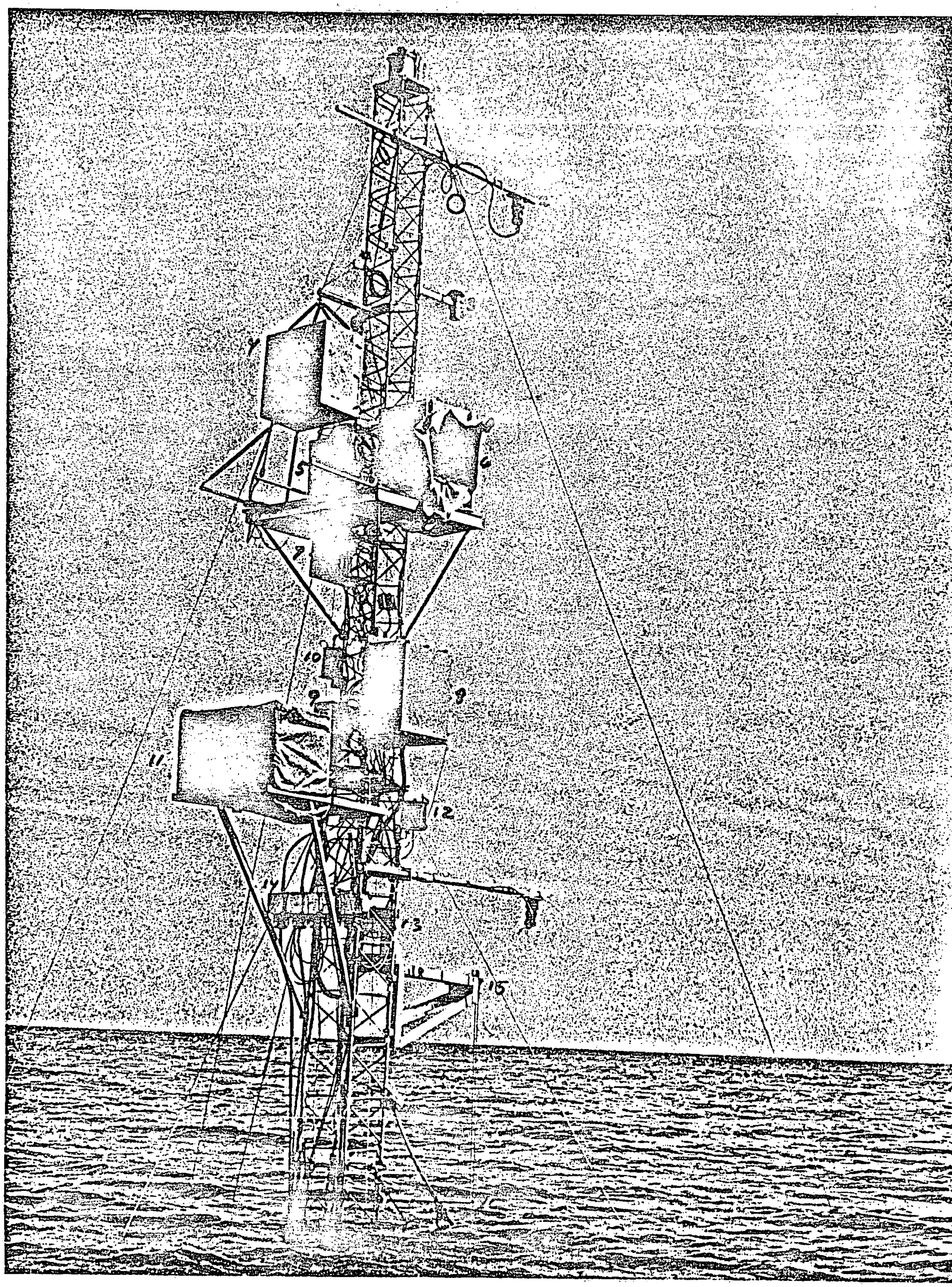
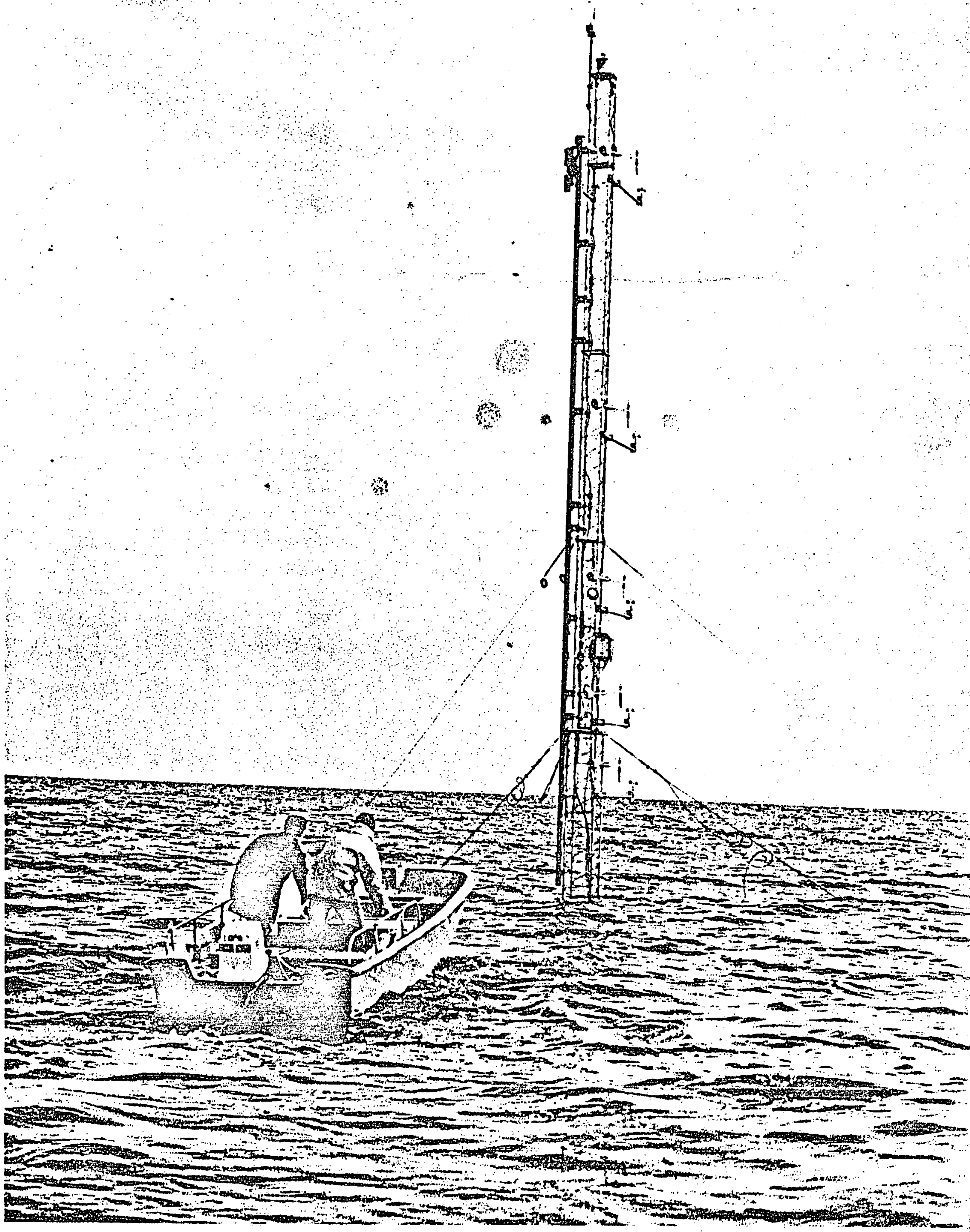


Fig. 2 - Proper Use of a Millard Tower



SECTION 2: PROBLEM DEFINITION - NEEDS

There are basically two types of requirements for scientific instrument towers, as seen by Engineering:-

(1) Small removable structures which can be readily transported to various locations in the Great Lakes region for studying short-term (one season - not winter) geographically-dependent scientific phenomena, on a very small one scientist scale.

(2) Large steady fixed platforms which can reliably accommodate present and future short and long term multi-disciplinary research of varying natures, throughout all seasons. These would be more or less geographically-independent studies.

The first need for light-weight removable structures can be satisfied by the existing guyed Millard towers and the "Self-mooring tube" tower, which have both been used extensively in the past at CCIW. There are very many limitations, however, to the use of these structures in scientific data studies, as described in detail in the Engineering report entitled, "A Dynamic Response Analysis of Three Guyed Instrument Towers Under Wave Forces" (ref. 1) 1/ Briefly, these towers should be restricted to either of two uses, as follows:-

(1) Guyed satellite towers for mounting of light instruments and sensors around a main equipment support platform, such as the large steady fixed platform mentioned above.

(2) Guyed support towers for small scale programs requiring very little instrumentation (ie: less than 300 lbs. total weight per tower) consisting of small size packages. These should

1/ This report is still in progress; the study has been completed although the report documentation is still underway.

SECTION 2: PROBLEM DEFINITION - NEEDS (Cont'd.)

be symmetrically mounted around the perimeter of the structure mast. (Fig. 2).

Another solution to the first requirement is the proposed "Portable Independent Platform (PIP)" which has already been specified by Engineering and was designed (April, 1975) through outside contract.

There is still a void, however, in satisfying the second type of need; a steady fixed platform which can be used for a wide variety of scientific and engineering studies over the long term, throughout even the winter seasons.

Future scientific programs are going to present ever-increasing instrumentation requirements, thereby demanding stronger and larger supporting structures. The Engineering Section also anticipates that interest in studying winter season air and water parameters, as well as long term changes over a year or more, will develop in the near future, which necessitates very strong ice-resisting structures.

This report presents a proposal and outlines the advantages and future potential of such a fixed platform.

SECTION 3: POTENTIAL OF FIXED PLATFORM

The following is a list of some of the projected potential scientific and science-related studies possible with a large, steady and reliable, fixed platform.

A. Scientific Research

(1) Air/Water Transfers

(2) Radiation

(3) Atmospheric Pressure

(4) Wave Energy

(5) Turbidity

(6) Sediment Transport

(7) Lake Chemistry

(8) Lake Biology

(9) Geology

(10) Seasonal Thermocline Studies (all year)

(11) Underwater Motion

(12) Surface Motion (oil spill research)

(13) Underwater Acoustics

(14) Electromagnetic Propagation

(15) Frazil Ice in Waves

SECTION 3: POTENTIAL OF FIXED PLATFORM

B. Science-Related Research/Development

(1) Radio-telemetry, Laser, Radar.

(2) Use of television, motion-picture cameras, sound transducers requiring a steady fixed reference.

(3) Test and evaluate newly-developed techniques and equipment in the field, under all atmospheric conditions (eg. "REX" System, underwater diving technology, etc.).

(4) Engineering analysis of wave and ice forces on structures.

(5) Assistance to AES, NRC, Ontario Water Resources Commission, etc.

SECTION 4: DESIGN OBJECTIVES

The following objectives are aimed for in the design of the fixed platform (See also ref. 2 and 3):-

1. Safety/Reliability

   (a) Maximum safety to personnel while working on the platform and underwater around or under the platform.

   (b) Maximum reliability (ie: minimum risk factor) to minimize risk of loss or failure of equipment or sensors during rough or calm weather conditions, thereby, saving costs and avoiding loss of scientific data.

   This will also attract users.

2. General

   (a) Installation in "shallow" water (12 metres) at a fixed desired location/depth.

   (b) The structure and installations should be aesthetically pleasing.

3. Scientific Requirements

   (a) Stability to limit maximum accelerations and vibrations which would move or damage the instruments/sensors or cause calibrations to stray.

   (b) Minimum airflow and water disturbance to sensors both above and below mean water level (MWL). Capability to mount long booms out from structure or high "towers" above structural interference preferable as well.

SECTION 4: DESIGN OBJECTIVES

3. Scientific Requirements (Cont'd.)

(c) Minimum electronic/electrical and magnetic interference to sensors and equipment through signal conductors and equipment.

(d) Maximum scientific data collection (ie: quality and quantity of useful data) ..... [see pt.(e) and "Operations"].

(e) Capability to perform long-term measurements throughout all seasons of the year, for up to 5 years.

(f) Accessibility to sensors/instruments for adjustment of calibrations. ..... [see "Operations" objectives.]

4. Operations

(a) Minimum time and effort of erection, installation, and set-up of equipment.

(b) Minimum underwater work/time in erecting the platform, and sensors.

(c) Accessibility (ie: easy approach) by small-, medium-, and large-sized craft in both calm and limited wave conditions.

(d) Minimum time and effort in maintenance and replacement of equipment and sensors, as well as with their mounting supports (ie: ease of daily operations.) ..... [also see pt.(g).

SECTION 4: DESIGN OBJECTIVES

4. Operations (Cont'd.)

(e) Ease of equipment and personnel boarding and removal from the platform/structure.

(f) Capability of unattended or remote-control-from-shore operation of sensors and drives under all weather conditions, (through all seasons).

(g) Maximum convenience and accessibility to sensors and equipment to minimize diving work (ie: readily detachable, preferably from above MWL).

5. Design and Construction

(a) Survivability of the structure under maximum expected storm wave and wind conditions, as well as winter ice loadings, while supporting the on-board instrumentation payload, without any structural failure. Bottom anchoring must resist overturning forces on structure.

(b) Maximum strength for stability and survivability conditions, as well as to increase the potential versatility of the structure to accommodate a higher number of larger scientific programs operating simultaneously. A high safety factor should exist to ensure the Safety/Reliability objectives also.

(c) Platform working area to accommodate the required number of scientific and operations personnel and equipment of many multi-disciplinary experiments and ease of daily operations. The structure should be designed with the capability of future expansion of the deck area(s).

SECTION 4: DESIGN OBJECTIVES

5. Design and Construction (Cont'd.)

(d) The design of the structure should minimize the wind and wave blockage which would increase loadings and sensor interference. This restricts the platform and equipment to above the maximum expected wave crest zone for the area.

(e) Materials and/or protective coatings to minimize rust and corrosion as well as to facilitate ease of repairs and modifications in the field or at the base site.

(f) The structure must satisfy all applicable Harbour codes and National Building (Safety) codes for the site area.

(g) The structural design time and complexity should be optimized for easy fabrication and installation in the field, and for scientific versatility.

(h) The weight and size of the basic structure (ie: or largest and heaviest component) must be within the maximum lifting capability of the transporting barge (e.g: McKeil "Cargo Master") and crane for placement and future removal from site if desired.

(i) Cost of purchase, installation, and operations time/maintenance in the field must be economically comparable (ie: considering man-hours and capital/operations costs) to that of the conventional guyed towers which have been used over the last 8 years.

(j) Minimum electronics/electrical design and manufacture time/effort and the number of interconnecting packages and cables.

SECTION 4: DESIGN OBJECTIVES (Cont'd.)

6. Versatility

(a) The installation must be capable of accommodating many multi-disciplinary scientific and engineering studies, simultaneously. (ie: facilitate expansion).

(b) It must have the capability to support both above MWL atmospheric sensors and below MWL shallow water sensors.

(c) The structure must withstand winter and summer "environmental" loadings over at least 5 years for carrying out both long term "seasonal" studies and measurements, and short term "one-season" programs.

SECTION 5: DESIGN ALTERNATIVES CONSIDERED

1. Supported or Guyed Type

The following two types of structures would meet the design objectives for the first need (ie: small removable structures):

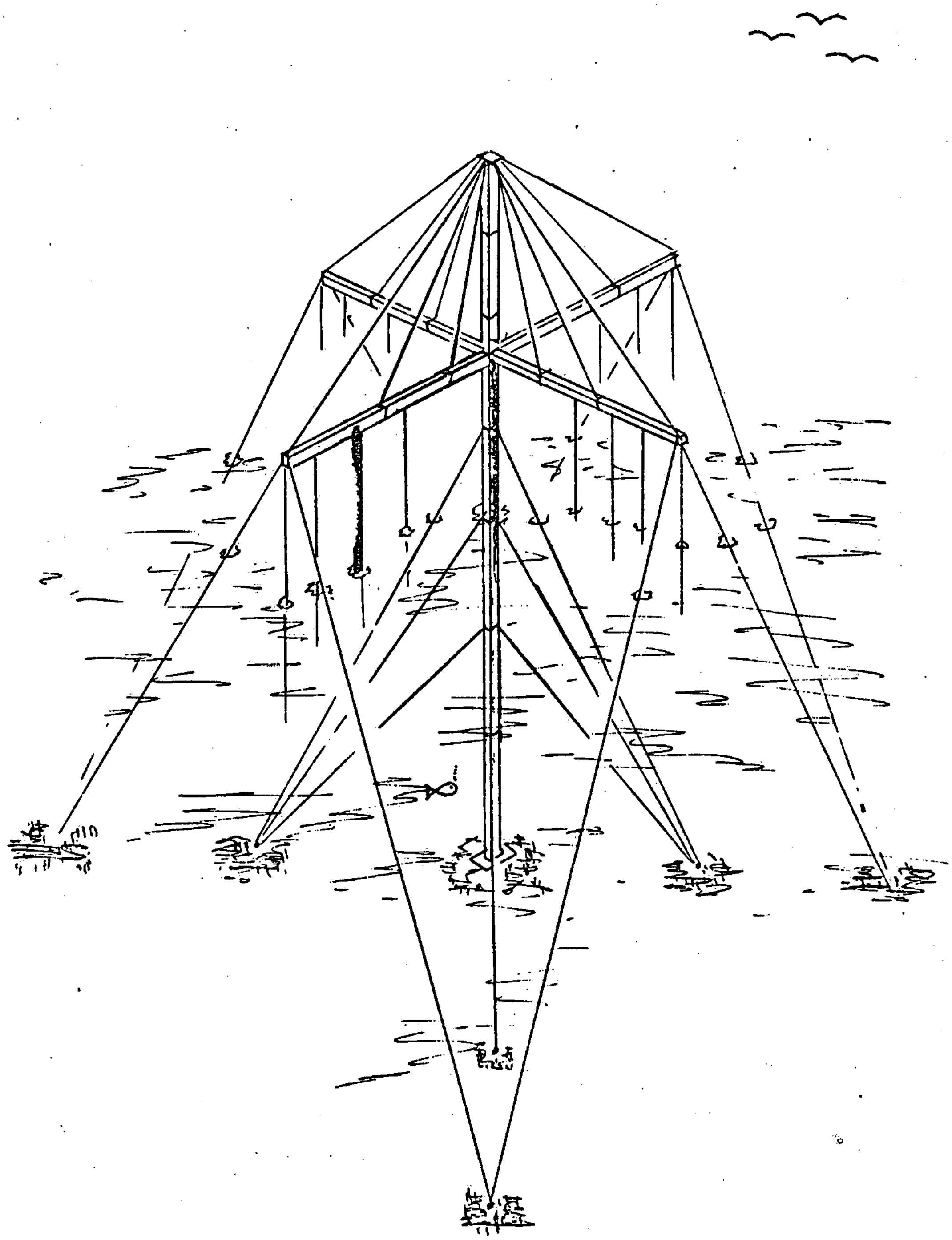
(a) Conventional single mast structures with small cantilevered platforms, guyed at a number of levels to anchors into the lake bottom (eg. Millards, Figs. 1, 2, 3; Self-mooring Tube tower, Fig. 4),

- Installed via CCIW divers and use of pontoon barge and "Shark".
- Removed in Fall, stored on CCIW dock.
- Purchased and/or constructed in-house.

(b) Small frame superstructure firmly mounted onto concrete pad or piles into lake bottom (eg. used Hydro tower, Fig. 5).

- Platforms attached inside corner legs of structure.
- Installed via "Cargo Master" barge towed by a tug. Aid of CCIW divers.
- Removed in Fall via "Cargo Master", stored on dock.
- Purchased (second-hand) from Ontario Hydro.

Fig. 3 - Spider-Web Configuration if Guyed Millard Tower was used to support 10-metre booms for hanging wave probes of MicroMet 76.



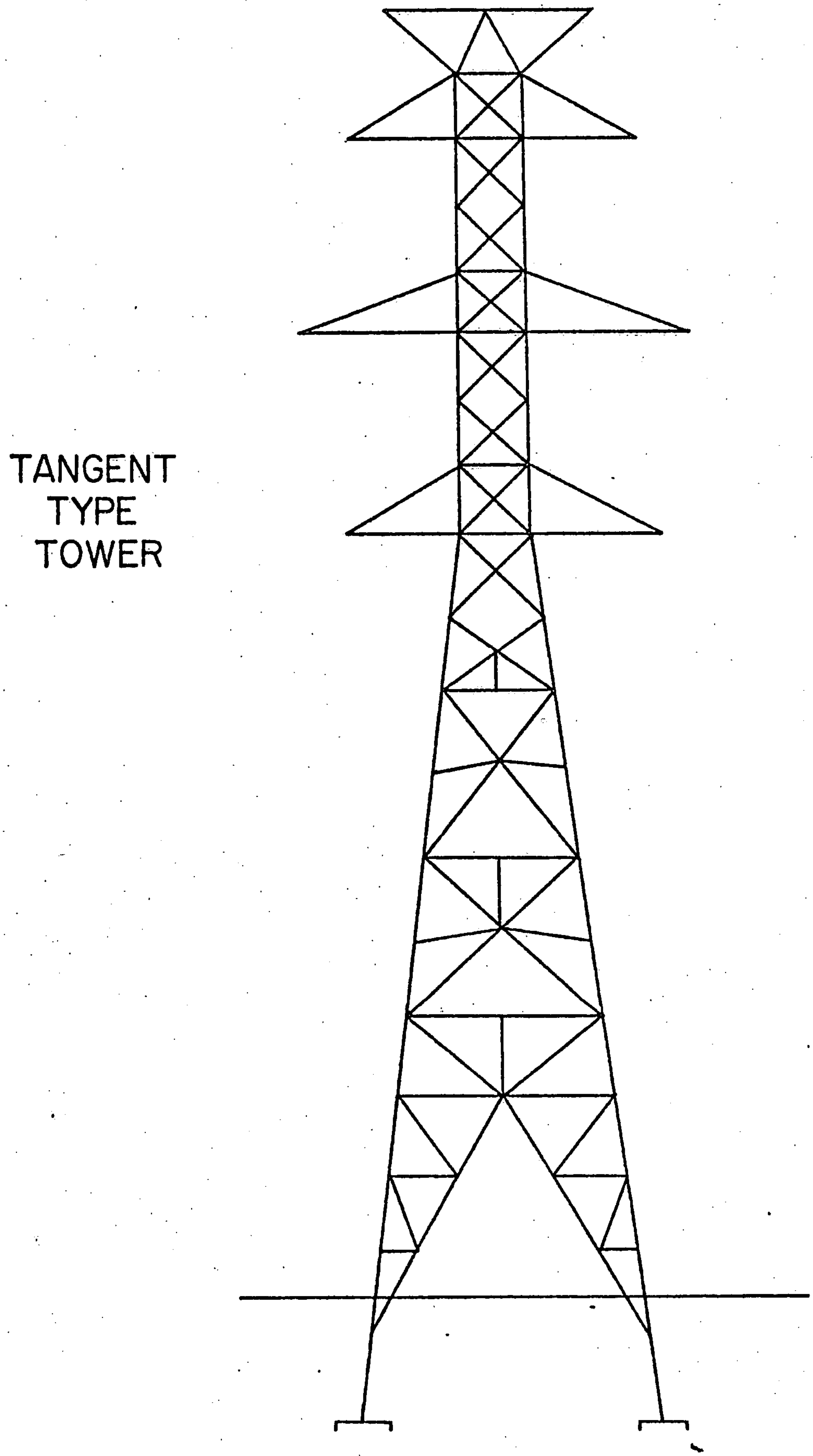


FIG. 5 - HYDRO TOWER

SECTION 5: DESIGN ALTERNATIVES CONSIDERED (Cont'd.)

2. Self-Supporting Type

These structures are considered, for satisfying the design objectives for the second need (ie: large fixed platform):-

(a) Large steel tubular support frame and deck (eg. U.S. Navy "Oceanographic Research Tower", Fig. 6).

- Anchored to bottom with circular or H-beam bearing piles driven through tube legs and deep into lake bottom.
- Designed in-house.
- Installed and fabricated by a pile-driving contractor with crane and pile-driver on barge. CCIW diver inspection only.
- Removed if desired by cutting off piles (at bottom) and transported to new site via "Cargo Master" barge.

(b) Jack-up Floating Large (eg. Translake I, Fig. 7).

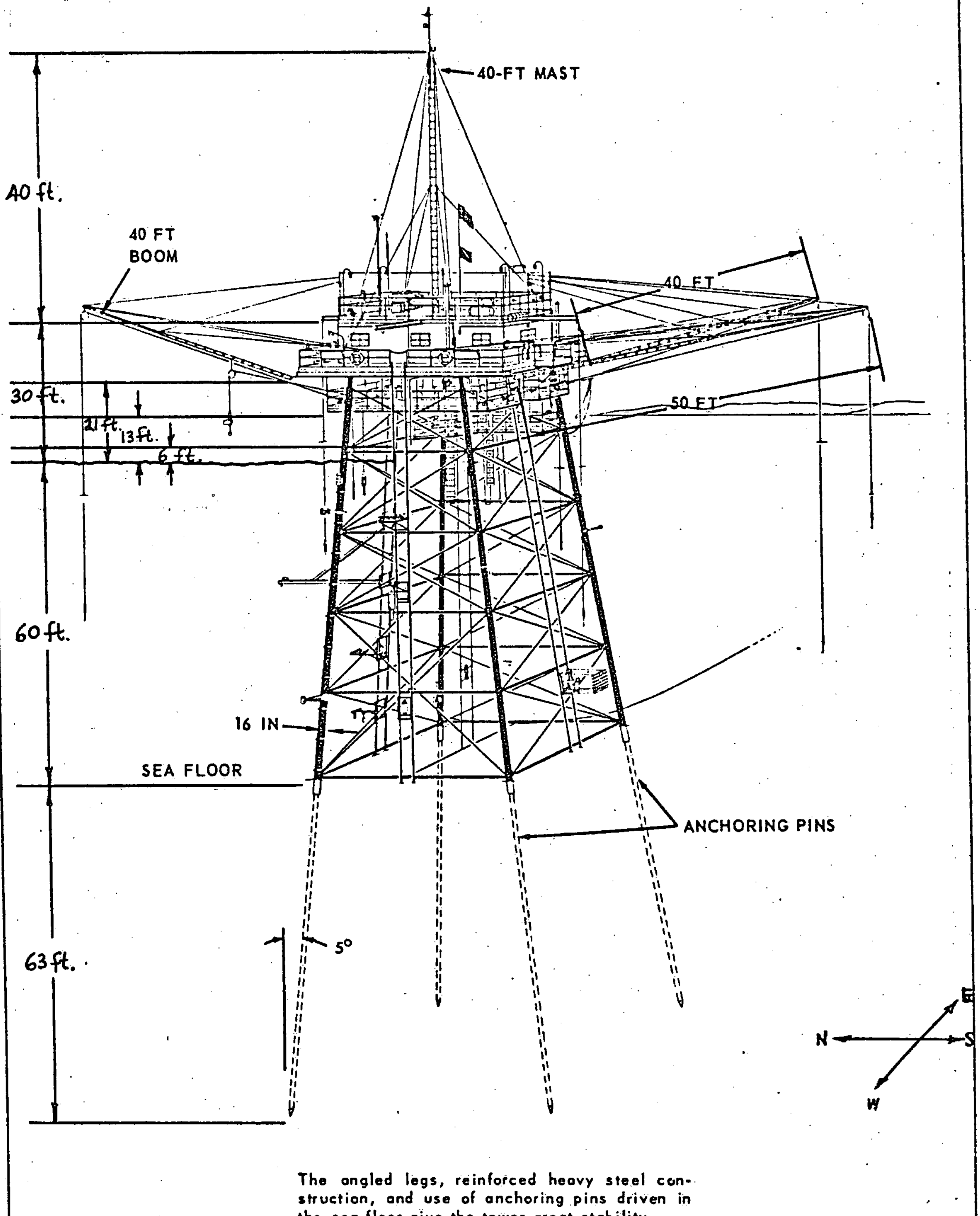
- Hull floated out to site by large tug.
- Legs hydraulically jacked down to lake bottom and hull jacked up above water level by leasing company crews.
- Removed by jacking up legs and towed away.
- Leased by the year.

(c) Monopod self-supporting structure.

- One large pile (concrete-filled) installed by pile-driving contractor with platform at top. (Fig. 8).

(d) Truss bridgework spanning two or three large piles (unguyed). (Fig. 9).

Fig. 6 - U.S. NAVY OCEANOGRAPHICS RESEARCH TOWER



The angled legs, reinforced heavy steel construction, and use of anchoring pins driven in the sea floor give the tower great stability.

(REF. 4)

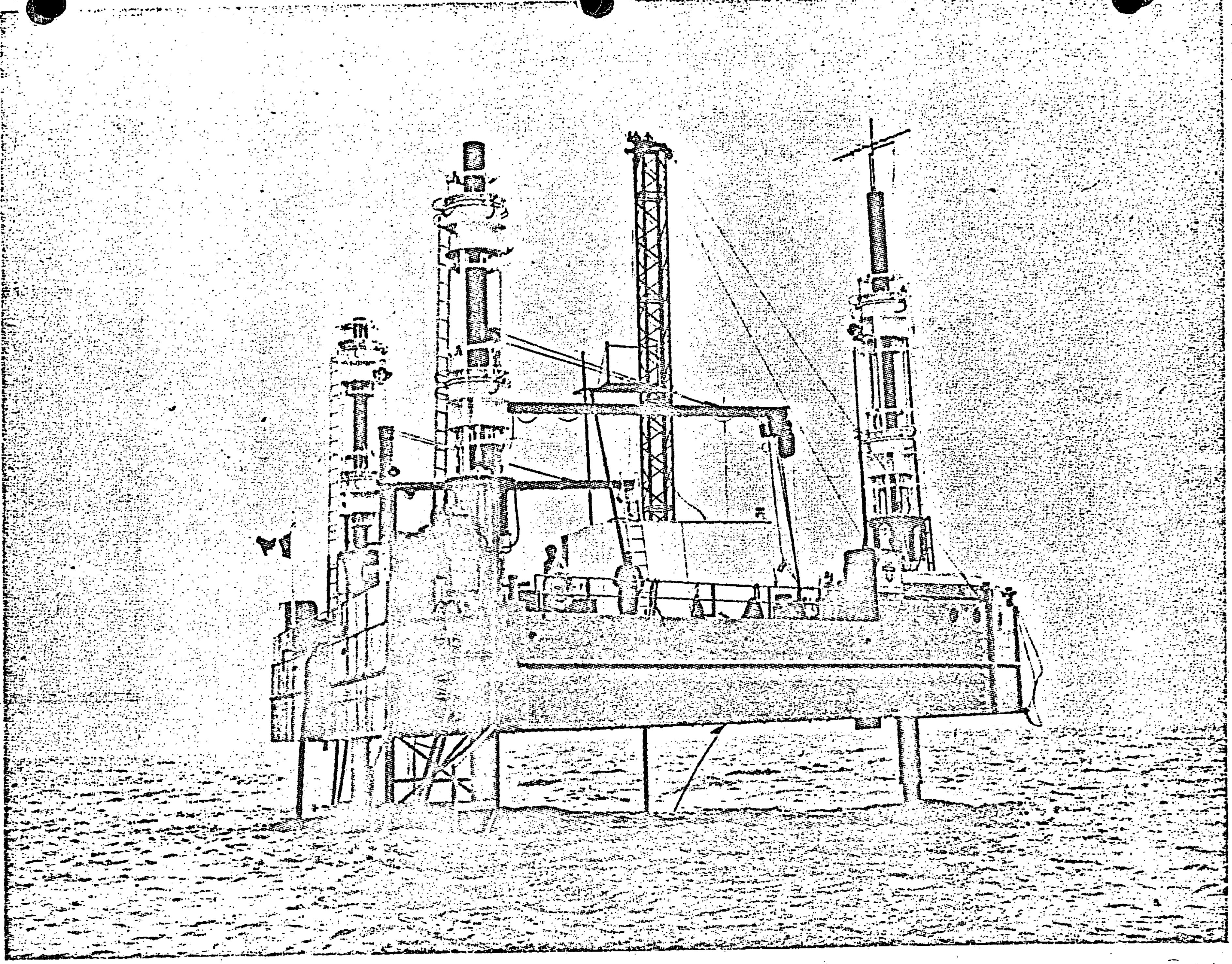


Fig. 7 - TRANSLAKE I FLOATING BARGE (UNDERWATER GAS DEVELOPERS LTD.)

Fig. 8 - MONOPOD STRUCTURE CONCEPT

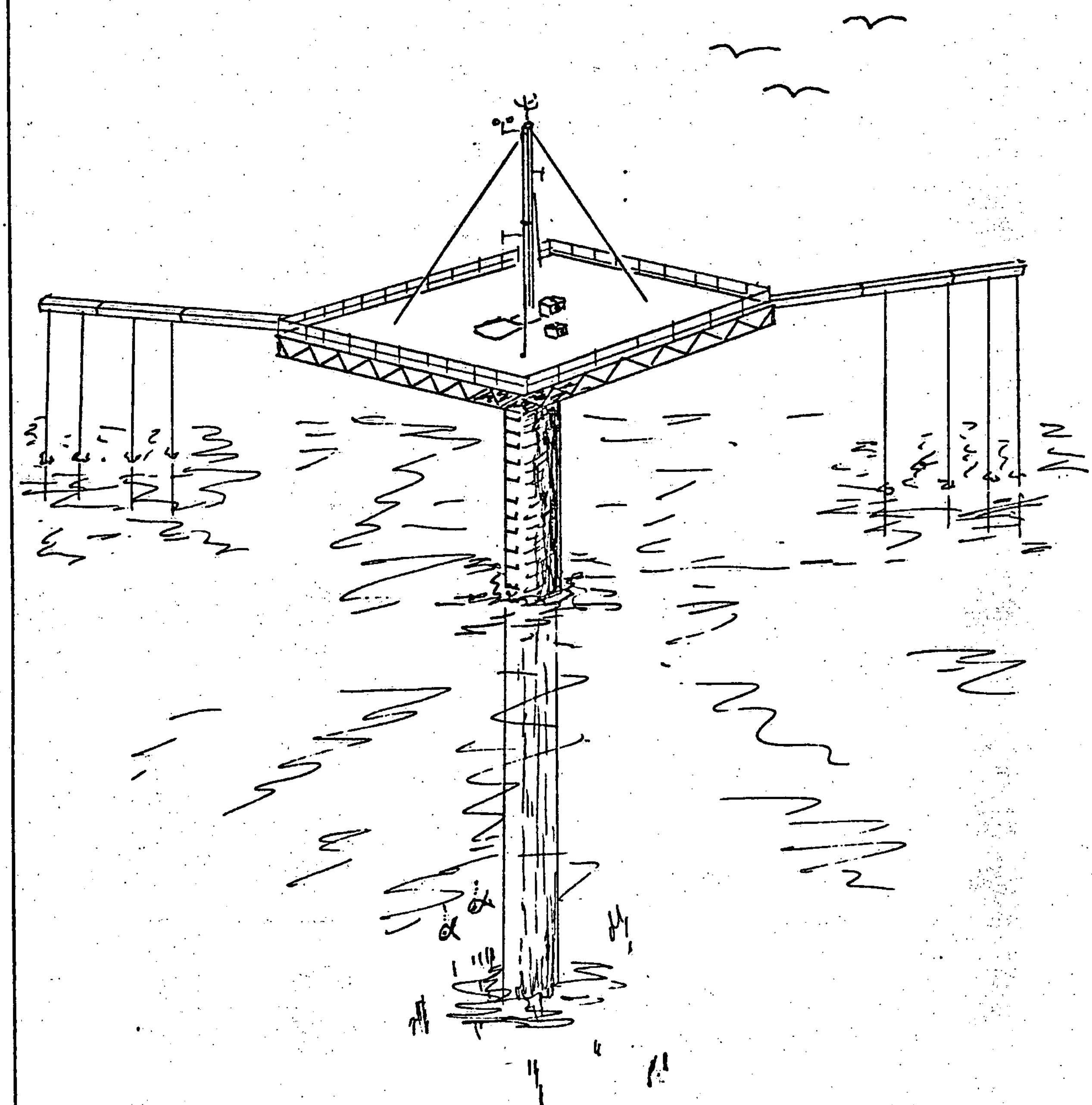
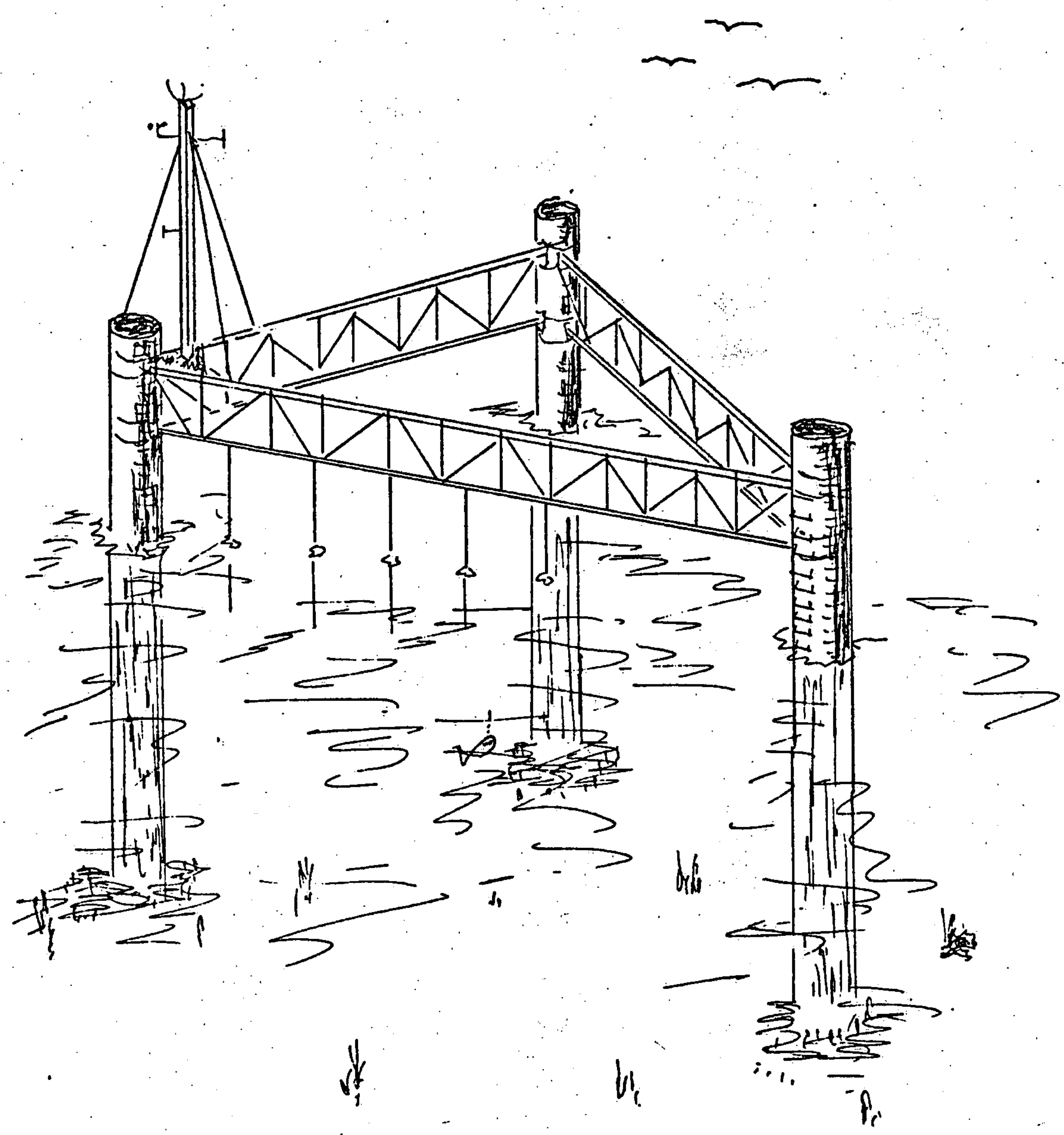


Fig 9 - Trusswork Spanning Piles



SECTION 5: DESIGN ALTERNATIVES CONSIDERED (Cont'd.)

3. Bottom Anchoring Methods Considered

Three alternatives for securing any structure onto the lake bottom were studied.

(a) Concrete pad floated to site, sunk, and the structure bolted to pad. (Fig. 10).

(b) Explosive anchors into bottom at each base footing of structure, used to "tie down" structure. (Fig. 11).

(c) Piles hammered deep into solid bottom sediments/rock under each base footing of structure. (Fig. 12).

Fig. 10 - Submersible Concrete Pad

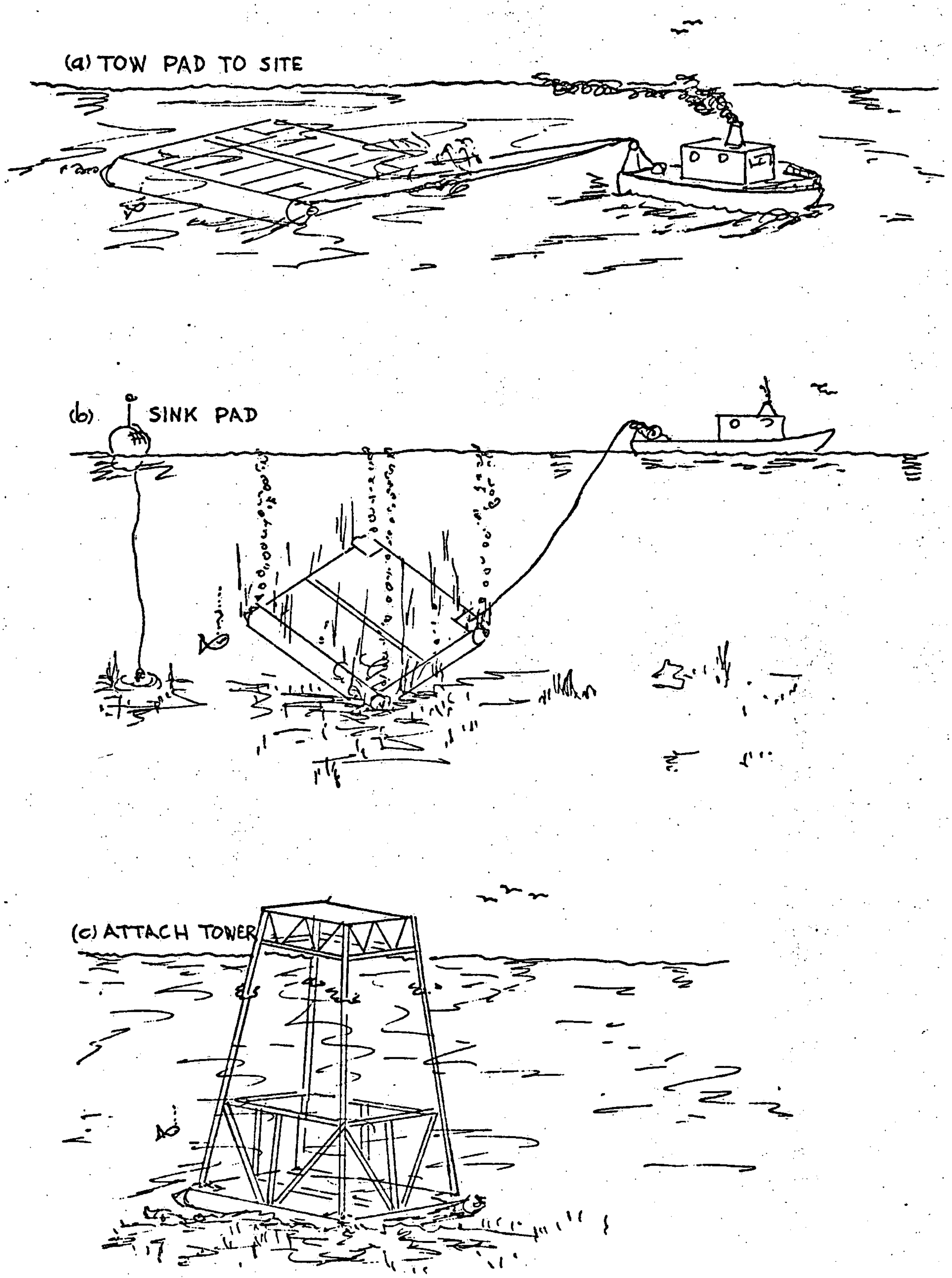


Fig. 11 - Exploded Anchors at each corner leg

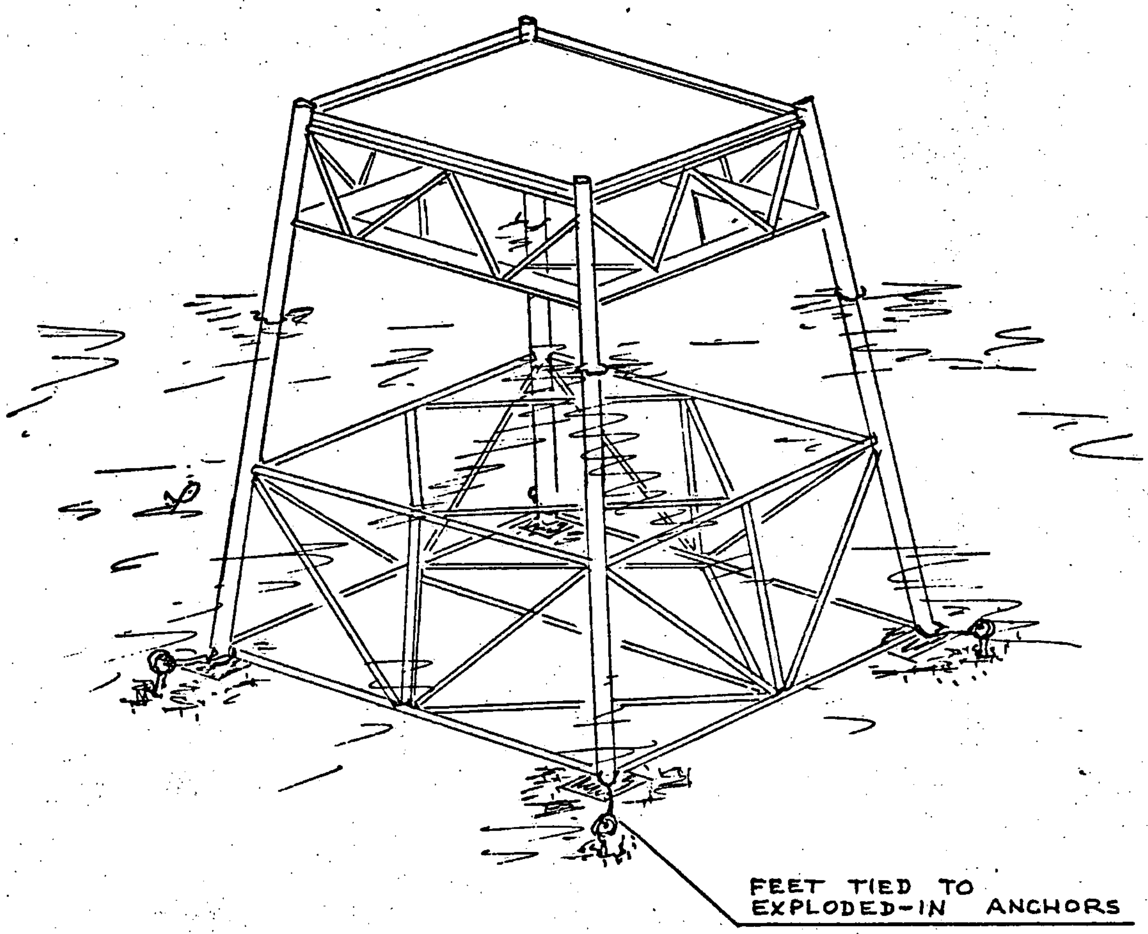
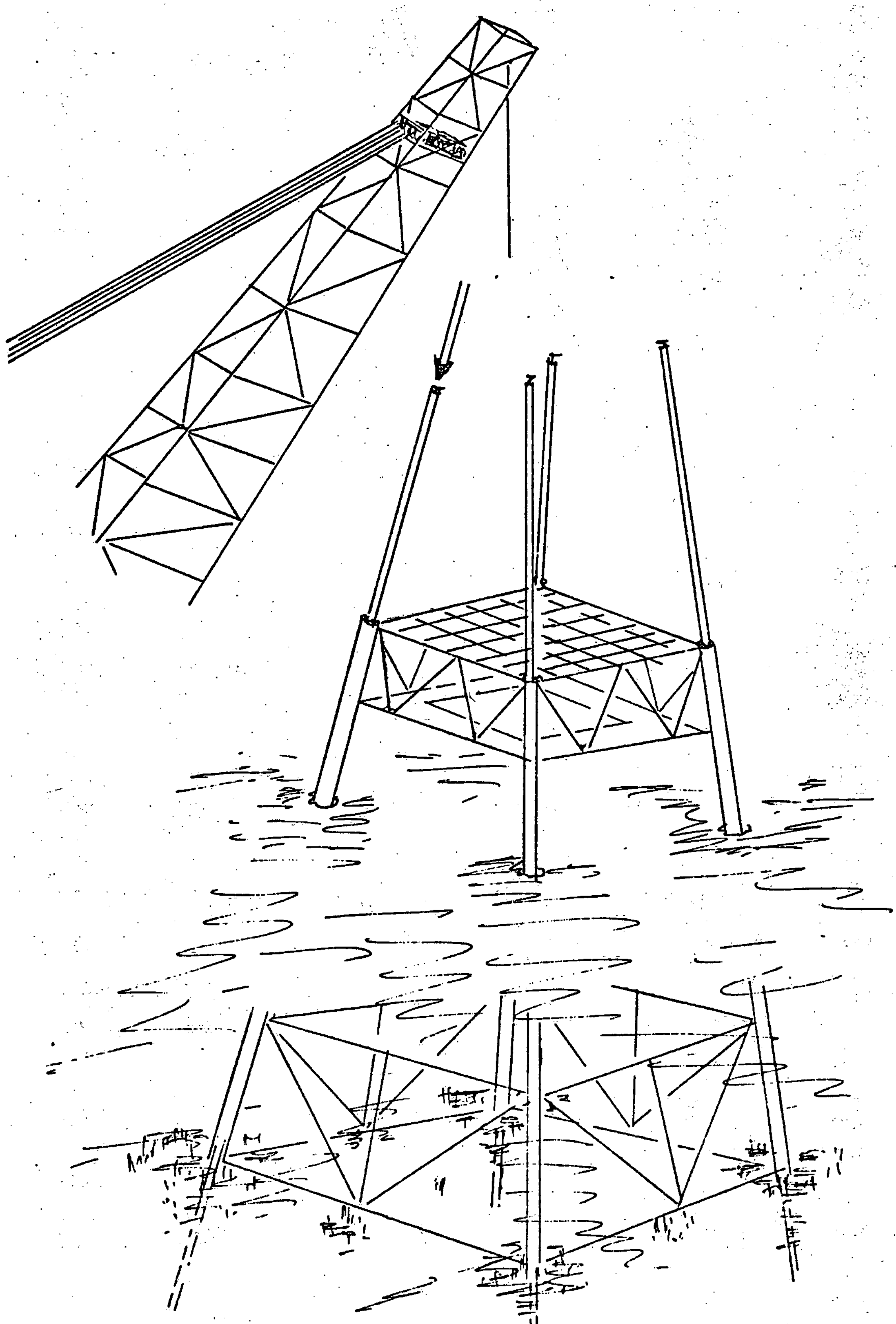


Fig. 12 - DRIVE PILES DEEP INTO LAKE BOTTOM



SECTION 6: FEASIBILITY STUDIES

This report is concerned only with presenting a proposal for a platform structure to meet the second need for a large fixed platform. Therefore, the two supported and guyed types of towers are considered only as comparisons to the self-supporting structures in the cost analysis and to illustrate the advantages of the proposed Offshore Platform.

Towers

The four self-supported alternatives described for a fixed platform have all been investigated considering the design objectives in Section 4 and how they meet the need.

- The monopod structure (c) was rejected because:-
  - (a) It would still be limited to a relatively small platform.
  - (b) The large supporting pile would cause considerable interference to sensors mounted in its vicinity.
  - (c) Large cantilevered booms stretching out from the monopod structure would cause instability in high wind and wave conditions and would not cover the range that a larger platform would give, unless a massive concrete structure was built.

- A truss bridge type structure spanning two or three piles (d) was rejected because:-
  - (a) The difficulty and time for field installation is considerably increased. Since work in the lakes is very dependent on reasonably calm wind and wave conditions, this presents unsafe and long drawn out installation procedures.
  - (b) Handling of the long (10 metre) truss at the site is very difficult.

SECTION 6: FEASIBILITY STUDIES (Cont'd.)

(c) Welding is necessary at the site from a spudded-in barge.

(d) The piles would not have intermediate bracing support between the top trusses and the lake bottom unless underwater welding was done or special bolted connections were designed.

(e) This type of structure fails to meet one main criterion for a fixed platform: it does not provide a large flat working platform on which to easily mount equipment and instrumentation, booms, profilers, Millard towers. Operations and maintenance would be difficult and inconvenient.

The above points all emphasize failure to meet one very important aim of the Offshore Platform concept:-

- reduce the amount of field work and the complexity of any work which must be performed at the site (ref. 2).

The jack-up floating barge platform was rejected next, almost completely on the basis of its exorbitant cost for rental (see Table I). However, it also fails to satisfy the scientific requirement of "minimum airflow and water disturbance to sensors, both above and below mean water level". The Translake I (Fig. 7) is one of the smaller barges offered for lease by Underwater Gas Developers Limited in Port Colborne, and yet its size and facilities far exceed those required for CCIW scientific studies at present.

SECTION 6: FEASIBILITY STUDIES (Cont'd.)

Reason for Piles as Anchoring:

A concrete pad base was rejected for the following reasons:-

(a) Since the pad is resting on loose bottom sediments, it has a tendency to shift or sink at one end or corner, due to sediment scouring. Turbulence on the lake bottom during storms causes movement of the pad, or for that matter, any bottom-resting structure. This "scouring" problem exists even for base pads of deep water oil-drilling structures, due to underwater currents in spite of their much larger masses and weights.

(b) If the pad does not settle on a level bottom, the structure must be levelled on the pad, requiring underwater adjustment.

(c) Calculations show that a 4,500. kg. hold-down force is required at each leg of the offshore fixed platform (Fig. 6) to resist overturning under 6 metre waves or moving pack ice forces. The concrete pad would have to weigh at least 18,000. kgs. (or more for a safety factor.)

(d) The heavy concrete-filled "barge" would have to be floated and towed out to the site, therefore, requiring huge flotation tanks (equivalent to approximately 100 @ 45 gallon drums). This would be a difficult and slow procedure. Location of the pad after sinking to the bottom could be far off the desired position.

(e) The cost of fabricating and installing such a "barge pad" and the amount of time to specially construct it would at least equal the cost of piles as anchoring pins.

SECTION 6: FEASIBILITY STUDIES

Reason for Piles as Anchoring: (Cont'd.)

(f) The effort required to disconnect the structure from the pad, if it is desired to move it, and to refloat the barge would be fairly complex. Maintaining stability while refloating the barge, and while towing it, presents a great design problem as well as many operations difficulties.

Explosive anchors at the feet of a structure would be the least expensive method of securing the structure and the easiest method for removal. However, they could not provide enough hold-down force to prevent the platform from lifting and overturning under the design ice and wave forces. The structure would still be resting on the bottom sediments, which again presents the problem of shifting and settling due to scouring.

Therefore, anchoring piles which are hammered into the lake bottom down to hard compacted silt and clay is recommended as the best method of securely fixing the platform. Since the structure would be welded to these piles, its weight would not be resting on the loose sediments, but instead taken by the piles. No shifting or settling of the structure can occur. In case it is ever necessary to remove the platform from the site the piles could be cut off, underwater at the base, and the platform lifted onto a barge. The piles could have welded spliced extensions added and be re-driven, at a new location.

A cost analysis summary is presented in TABLE I for procurement and installation of the four types of structures described. Design and operations man-months in TABLE II are typically based on the MicroMet '76 program using a reference comparison with the conventional Millard towers used over the last 8 years in CCIW scientific programs.

TABLE 1 = CAPITAL AND O & M COSTS

COST AREA	CONVENTIONAL TOWERS (4 MILLARDS)	HYDRO TOWERS (2 Hydro Towers, 1 Tube)	FIXED PLATFORM (1)	JACK-UP FLOATING BARGE (2)
1. Procurement	25K / 2 yr. (4) x6 (3) yr. = 75K	20K / 2 yr. x6 yr. = 60K	55K	14K / month x6 yr. = 1,008K
2. Installation:				
(i) Anchors -	15K	4K	-	-
(ii) Piles -	-	10K	15K	-
(iii) Operation (5) -	4K x twice / yr. (6) x6yr = 48K	6Kx twice / yr. x6yr = 72K	5K + .5K (5) = 5.5K	1K + .5K (5) = 1.5K
	63K	86K	20.5K (7)	1.5K
Total Costs:-	$138.K	$146.K	75.5K	$1,009.5K

Footnotes:-

(1) Preliminary verbal quotes only from Birmingham Construction and Canadian Dredge & Dock (27 Feb., 1975).

(2) Written quotation for leasing from Underwater Gas Developers Limited.

(3) All costs are projected at present rates, over a six year program.

(4) Millard tower structures renewed every 2 years.

(5) Includes diving @ $10./hr. and "Shark" @ $200./day (ref. Jack Roe, Tech. Ops.).

(6) Installation and removal of towers each year.

(7) Indications are that this figure could rise to $120K (or more), depending on design, pile-driving depths, etc.

TABLE II : MAN-MONTHS FOR MICROMET '76 PROGRAM

COST AREA	CONVENTIONAL TOWERS (4 MILLARDS)	HYDRO TOWERS (2 HYDRO TOWERS,1 TUBE)	FIXED PLATFORM	JACK-UP FLOATING BARGE
1. Engineering (1)				
(a) Electronics				
(i) Design	5.0 x 6 = 30.0		4.5 x 6 = 27.0	
(ii) Construction	5.5 x 6 = 33.0		3.8 x66 = 22.8	
(iii) Misc.Mat'ls.	--		5Kx6yr.Savgs= 30K	
(iv) Installation	1.5 x 6 = 9.0		1.0 x 6 = 6.0	
(v) Maintenance	2.0 x 6 = 12.0		1.0 x 6 = 6.0	
	84.0	84.0	61.8	61.8
(b) Mechanical (2)				
(i) Design	4.0 x 6 = 24.0		3.0+3.0 x6 = 21.0	3.0 x 6 = 18.0
(ii) Construction	5.0 x 6 = 30.0		.5+3.5 x6 = 21.5	3.5 x 6 = 21.0
(iii) Installation	1.5 x 6 = 9.0		1.0 x 6 = 6.0	= 6.0
(iv) Maintenance	1.0 x 6 = 6.0		.5 x 6 = 3.0	= 3.0
	69.0	69.0	51.5	48.0
2. Operations (3)				
(i) Installation &Removal of Towers.	1.0 x 6 = 6.0		-	-
(ii) Instrument Set-up.	1.5 x 6 = 9.0	-	.75 x 6 = 4.5	
	15.0	15.0	4.5	4.5
Total Man-Months:	165.0	165.0	117.8	114.3

Footnotes:-

(1) Estimated for Micromet '76 by J. Valdmanis (Electronics Engineering).

(2) Estimated for Micromet '76 by W. Gibson (Mechanical Engineering).

(3) Estimated for Micromet '76 by J. Roe (Technical Operations).

SECTION 6: FEASIBILITY STUDIES (Cont'd.)

Summary of TABLES I and II

An analysis of Tables I and II shows that the Fixed Platform type of structure, which can remain in the water all year round for at least six years, offers a cost savings of up to $63,000.[1/] and 47.2 man-months (4 man-years), when compared to the Conventional guyed Millard towers, over a 6 year service life. This does not include an estimated 50% reduction in time at the site for scientific technicians during the data collection period, due to greater working convenience and minimal need for re-calibration of the instruments since the platform is very steady and free of high accelerations.

Advantages of Fixed Platform

1. Safety/Reliability

   The platform is large and stable with a sturdy support structure and safety railings around the perimeter, thereby offering safe convenient working conditions for personnel at all times.

   A strength safety factor greater than 10:1 minimizes the risk to personnel as well as to equipment and instrumentation even during storm conditions.

1/ This is based on $75.5K. If the cost was $120.K, then the capital cost savings are reduced (probably insignificant over 6 years), but the big advantage still exists in the 4 man-years savings.

SECTION 6: FEASIBILITY STUDIES (Cont'd.)

3. Aesthetics

The self-supporting structure is a clean and balanced design with no guy wires. It may be painted for a clean appearance and to be easily seen by passing boats.

4. Scientific Requirements

(a) The stability of the platform is provided by its wide stance (legs angled out 10°) and secure anchoring piles. Movement and accelerations at the top of the platform are minimized to provide a very steady "fixed reference point", mandatory for water motion studies of waves, currents and turbulences. This also permits use of television and motion picture cameras not possible with a vibrating guyed-mast structure. Calibrations of sensors will not stray, due to lack of movement and vibration.

(b) The only parts of the whole structure which protrude through the air/water interface (ie. the wave zone) are the supporting pipe legs themselves. Bracing in this zone has been purposely omitted in the design to present a free undisturbed section for instruments.

The water and air turbulence from these circular legs is a minimum. By virtue of the great distance between each of the legs (9-10 metres), the sensors will see very little interference. The strength and stability of the structure permit the use of long booms and deck towers to extend the range of instruments and sensors at the site, and to further increase the distance from any platform interference.

SECTION 6: FEASIBILITY STUDIES

4. Scientific Requirements (Cont'd.)

(c) The concentration of the equipment on one platform permits much shorter electrical cables and fewer electronics buffering cans, thereby minimizing electrical/electronic interference to sensors.

(d) Operations time in the field is much reduced which means greater quantity of data collection.

(e) The strength of the structure to withstand ice and wave loadings permits long term, all-season, measurements in the lakes.

(f) Calibration to the instruments can be made on site because of easy access from a sturdy platform.

5. Operations

(a) Once the platform is installed, the seasonal withdrawal and installation of towers previously required is eliminated. Set-up time for scientific instruments and equipment is reduced also. This frees more time for actual data collection throughout a longer season.

(b) Underwater work is eliminated for tower installation each year, and can therefore be concentrated on instrument deployment and set-up.

SECTION 6: FEASIBILITY STUDIES

5. Operations (Cont'd.)

(c) The design of the structure allows easy approach by many small and large CCIW crafts (ie. from 13 foot Boston-Whalers to the 70 foot Advent). Approach during 2-foot chop is also possible.

(d) Operating and maintenance costs are minimal. An annual inspection underwater is all that is necessary. Some painting may be advisable every two years.

(e) This platform allows both local operation of instruments and recording from the platform and remote-control operation and recording from shore.

6. Design and Construction

(a) The structure has been designed to withstand large waves (up to 6 metres) as well as pack-ice loading during winter conditions. This provides maximum reliability for the safety of instruments and equipment.

(b) The main platform deck, with all equipment, is 6 metres above the mean water level; out of the maximum force and interference wave zone.

(c) The underwater structure should be completely coated with a coal tar paint to prevent rusting and corrosion. The above water structure and deck will be painted for aesthetic reasons, weather protection and boat safety. This will also facilitate ease of cleaning and maintenance.

SECTION 6: FEASIBILITY STUDIES

6. Design and Construction (Cont'd.)

(d) All construction safety codes have been met to provide for maximum safety to personnel and equipment.

(e) Attachment of any scientific instruments and equipment, both underwater and above water, is simplified by provision of pre-attached standard design brackets on the structure.

(f) The weight and size of the platform structure are within the capabilities of several local barging and crane companies.

(g) Examination of the cost analysis TABLE I shows that the savings in capital and operations costs as well as man-hours savings are considerable, over the conventional Millard towers and the jack-up drilling barge.

(h) The amount of electronics and electrical equipment and cabling is minimized by the concentration of these components on one platform.

7. Versatility

(a) The strength and size of the platform can accommodate multi-disciplinary studies, simultaneously if desired. The platform has the capability to support all future requirements within the next five years or more. Future expansion to the working area and increased payload are possible.

SECTION 6: FEASIBILITY STUDIES

7. Versatility (Cont'd.)

(b) Both under water sensors and above water atmospheric sensors can be accommodated.

(c) Short term or long term experiments can be carried out since the structure is designed to withstand all seasonal conditions.

Disadvantages of Fixed Platform

1. The fixed platform structure cannot be easily or quickly removed from one site, transported, and reinstalled at another site. It is not intended to be a "portable" platform as is the "PIP" Tower, but instead to provide a facility for long term studies. It is possible, however, to cut the piles off at the bottom (ie. mud-level), lift the platform via a large crane into a barge, and tow it to a new site. Pile extensions can then be spliced onto the remaining lengths and re-driven. This procedure could cost approximately $15,000., or more depending upon transporting distance to a new site and length of the driven piles.

2. The pile anchoring method for securing the fixed platform to the bottom is very dependent upon sediments and soil properties at the site location. The soil must provide enough friction on the piles to prevent pull-out as well as enough shear to resist side forces on the structure. If piles cannot be driven deep enough, then either another location must be chosen or the piles must be drilled into the bottom (ie: through boulders, etc.). Drilling the piles would be a slow and expensive procedure. For this reason, some time and money should be spent to obtain several soil profiles for analysis and to determine the feasibility of driving piles at the desired site.

3. The capital output in the first year would be greater than would the conventional guyed towers.

4. Strain-gauging of any underwater members of the structure for future force analyses must be provided for at the time of fabrication, as the gauges cannot be applied in water. This, therefore, increases the initial procurement cost of the platform, if they are desired.

SECTION 7: FINAL PROPOSAL OF ORP

After thorough discussions and feasibility studies, considering how each alternative satisfies the design objectives, Engineering recommends the fixed Offshore Research Platform (ORP) Fig. 13. This type of structure is proposed in this report for use in scientific studies requiring instrumented towers in the lakes, at a fixed location. A concept sketch of ORP, illustrating the Hydraulics Research Division's MicroMet '76 program requirements is shown in Fig. 14. This program is the first anticipated use of ORP in the 1976/1977 fiscal years.

OFFSHORE RESEARCH PLATFORM

Design Specifications

1. Safety/Reliability

   (a) Safety factor of structure under maximum operating loads (with payload) .... > 10:1

   (b) Reliability (function of safety factor) Reliability against loss or failure of instruments and sensors depends upon attachment design .... Approaching 100%

   (c) Projected Life ....10 years or greater.

SECTION 7: FINAL PROPOSAL OF ORP (Cont'd.)

2. General

(a) Installed depth of water .... 12 metres

(b) Total height .... 18 metres

(c) Platform height above mean water level .. 6 metres

(d) Platform Size .... 9.14 metres square

(e) Maximum payload capability .... 13,000.Kg.(+)

(f) Colour(s) Schedule .... White/Red/Yellow

3. Scientific Requirements

(a) Stability

(i) maximum accelerations at platform .... < 1.g.

(ii) maximum displacement at platform .... 3.0 cm.

(iii) maximum rotation at platform .... < 1.0°

(b) Water disturbance (wave zone) .... 1 m. radius around each leg.

SECTION 7: FINAL PROPOSAL OF ORP (Cont'd.)

4. Design/Construction

(a) Survivability

(i) Wind speed .... 30 m/sec. gusting to 36 m/sec.

(ii) Peak wave height (trough to crest) ... 6 metres

@ Wave length .... 35 metres

@ Wave period (minimum)............... 5 sec.

(b) Stability

(i) see Scientific Requirements (3), (a).

(ii) Structural natural frequency (with piles) .... 6.5 cps. (estimated)

(c) Weight (bare platform) .... 23,000. kg. (approx.)

(d) Corner Leg Angles (from vertical) .... 10°

(e) Structure material .... Structural Steel

(f) Protective Coatings

(i) Primer................................ Red-oxide primer Undercoat

(ii) Below waterline....................... Coppers 50 black bituminous paint

SECTION 7: FINAL PROPOSAL OF ORP (Cont'd.)

(iii) Above waterline: Legs.............. Dayglo red/yellow stripe

Bracing/Deck...... Dayglo white enamel

U.V. protection... Filterray

(g) Anchoring Piles

(i) Size .... 8" x 8" H-beam 36 lb./ft. (or 10" Ø pipe)

(ii) Depth.............................. 9 M. (minimum) to 13 M. (max.)

Existing Fixed Platforms

The basic concept for the proposed Offshore Research Platform originated from a similar installation in 18 metres of water off Mission Beach, San Diego, California. The U.S. Navy Electronics Laboratory (NEL) (reference 4) has constructed an oceanographic research tower for studying marine environmental problems (Fig.6). It has operated quite successfully for sixteen years (ie.: since 1960), providing facilities for many scientific studies. NEL found it necessary after several years to expand the tower's work area because of increasing demands for instrumentation and new research.

Plan of Action

The following plan of action for design, procurement and installation of ORP is recommended:

SECTION 7: FINAL PROPOSAL OF ORP (Cont'd.)

Mechanical Engineering

(1) Complete detailed design and specifications (in-house) with outside consultation, for outside fabrication and installation contract.

(2) Complete a soil profile analysis in the site vicinity to determine resistance to platform overturning forces. The exact desired location of the platform must then be finalized with the scientists.

(3) Coordinate contract and inspect platform during construction.

(4) Inspect installation and acceptance after completion.

Technical Operations

(1) Consultants in design to Mechanical Engineering.

(2) Diving inspection during installation.

It would be very helpful to visit the existing U.S. Navy Platform in California and to talk with the scientific users and maintenance people.

Power Considerations and Recommendations

After installation of the platform (about 15 April, 1976) the existing underwater power and signal cables running from the Trailer on shore to the tower site, if the Confederation Park Beach site is chosen again, must be secured to the platform. It is suggested that these cables be lashed up one tower leg (ie: the inshore south-west corner beside the ladder). The termination boxes will be mounted on the platform deck where most convenient (as recommended by Electronics Engineering).

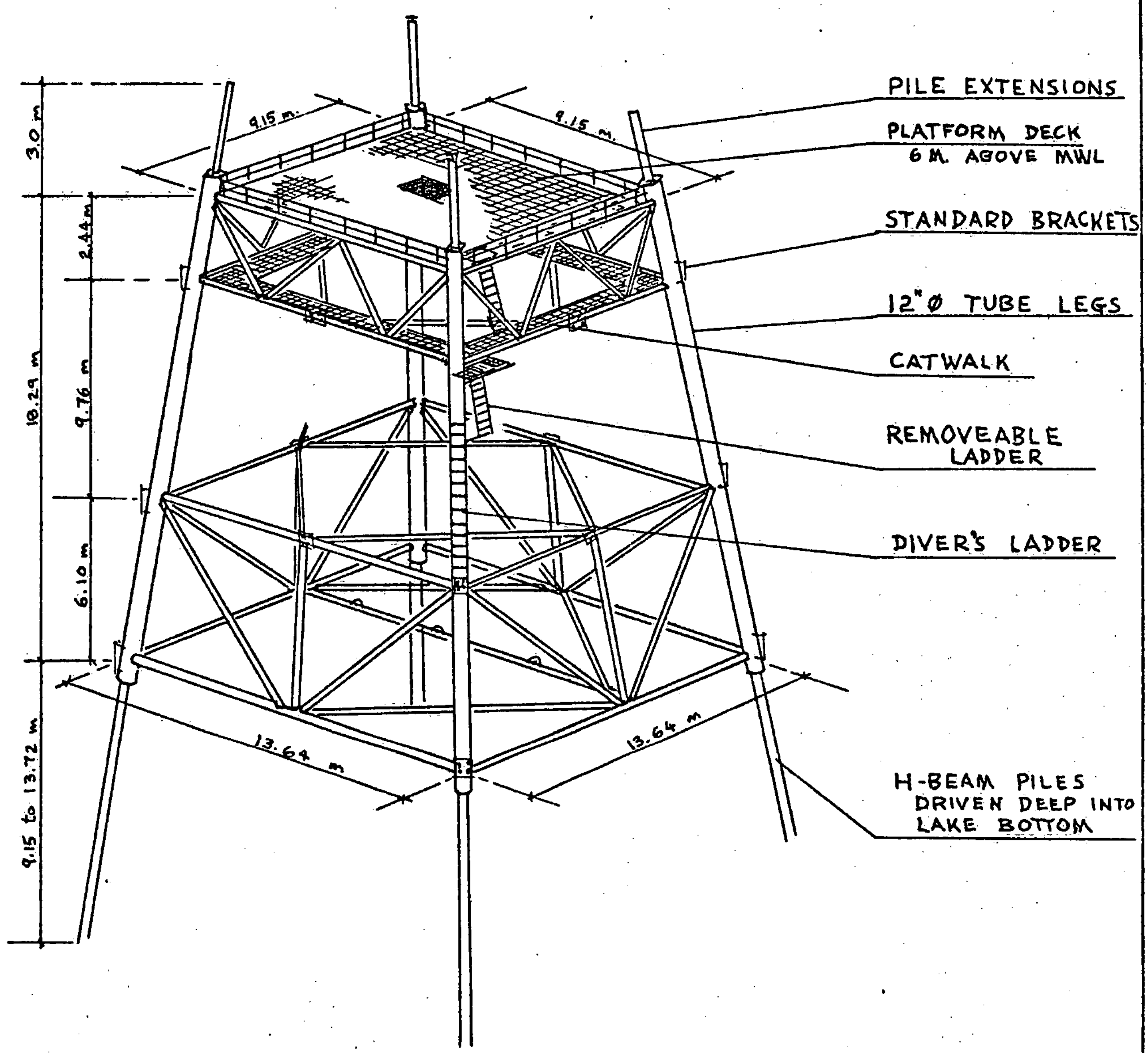
The Electronics Engineering Unit recommends that increased power supply at the platform site be provided. The present power capability at the site is only 1 KW. This will not be sufficient for future tool and equipment power requirements as larger programs are initiated each year. The Engineering Section therefore recommends that a larger power distribution facility be designed and installed to meet expected future demands.

Strain-gauging for Future Analyses

It would be extremely worthwhile to have some strain-gauges applied to several of the structural members of the platform so that forces on the platform could be measured, in the future. Wind, wave and ice force data on structures is lacking, world-wide. Therefore, much useful information could be gained from these measurements. A structural analysis resulting from monitoring of these forces would also provide a good evaluation of the design, for future improvements.

Strain-gauges could be applied to the structural members above water, at any time in the future, after installation. However, underwater members, which are of great importance, should also be monitored. The gauges on these members must be applied, on land, during fabrication. This should be planned in the initial design and contract.

Fig. 13 - PROPOSED OFFSHORE RESEARCH PLATFORM



SECTION 8: REFERENCES

1. A Dynamic Response Analysis of Three Guyed Instrument Towers Under Wave Forces.

   - W. Gibson, Mechanical Engineering
     June, 1975

2. Engineering Tower Analysis - Preliminary Field Report.

   - W. Gibson, Mechanical Engineering
     January, 1975.

3. Field Analysis/Tower Trials.

   - J. R. Compton-Smith, Technical Operations
     January, 1975.

4. The U.S. Navy Electronics Laboratory's Oceanographic Research Tower -- Its Development and Utilization. NEL Report 1342.

   - E. C. LaFond, U. S. Navy Electronics Laboratory
     December, 1965.