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THE USE OF HI-FIX IN INDIAN WATERS

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INTRODUCTION

Until the early sixties, hydrographic surveys in Indian waters were carried out by the classical method of position fixing with the use of sextant angles and station pointer. This necessitated extensive triangulation, building up of a number of sounding marks on the land and, often, laying of beacons at sea to extend the positioning control seaward. Beyond such extensions, position fixing was dependent on dead reckoning and astro fixes in surveying ships. Accurate hydrographic surveying was therefore restricted in range to good visibility, daylight hours and fair weather conditions up to about 15 miles from the coast. In areas of strong tidal currents, such as the Gulf of Kutch, Gulf of Cambay and Hugli River, position fixing and sounding on pre-planned lines was exceedingly difficult, and surveys could not always be completed satisfactorily without loss of time.

The advent of Hi-Fix heralded a new era in hydrographic surveys around India. This portable and precise Radio Position-Fixing Aid, with ability to provide two-range or hyperbolic mode fixes accurately at long range, enabled the hydrographic surveying organisations to undertake surveys with precision at considerable distance from the mainland, at all hours of the day. Thus, during the last 10 years the Hydrographic Department has used 3 Hi-Fix chains for hydrographic surveys. One of these chains has also been used successfully for acceptance trials of newly built ships. Each of the major ports at Bombay, Madras, Calcutta and Vishakhapatnam have permanently sited Hi-Fix or Sea-Fix chains for dredging and survey control. The Oil and Natural Gas Commission has a Hi-Fix chain with which off-shore waters have been explored for oil and gas, and the Geological Survey of India has recently acquired such a system for mineral exploration off-shore.

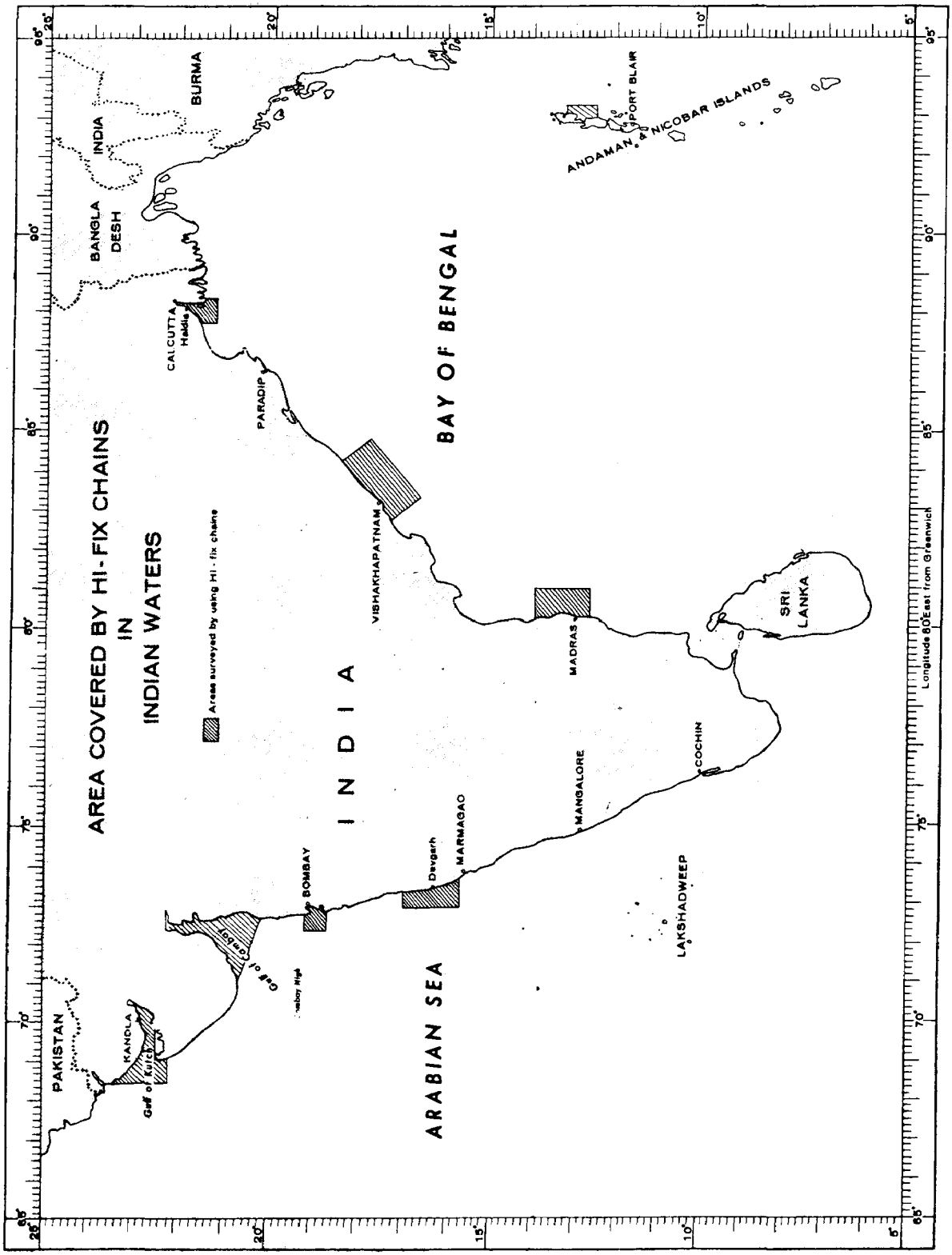
AREA COVERED BY HI-FIX CHAINS
IN
INDIAN WATERS
Areas surveyed by using Hi-fix chains
INDIA
BAY OF BENGAL
ARABIAN SEA
BURMA
INDIA
BANGLA DESH
PAKISTAN
SRI LANKA
CALCUTTA
Haldia
PARADIP
VISHAKHAPATNAM
MADRAS
COCHIN
MANGALORE
MARMAGAO
Dabhol
BOMBAY
KANDLA
Gulf of Kutch
Gulf of Cambay
Bombay High
LAKSHADWEEP
PORT BLAIR
ANDAMAN & NICOBAR ISLANDS
Longitude 80° East from Greenwich

Fig. 1

The successful use of Hi-Fix equipment in Indian waters may be seen from figure 1. Some of the areas shown have permanently sited chains for regular resurveys. The coverage of these waters with precision surveys in large areas, up to 50-60 miles from the coast, has been possible largely due to the availability of Hi-Fix. This paper summarises the experience of various organisations in the use of Hi-Fix in Indian waters, and highlights points of special interest to surveyors.

MODE OF HI-FIX OPERATION

The weather and seasonal conditions around India restrict hydrographic surveying and off-shore exploration activities to a period of about 7 months between each monsoon season. This period commences every year in early October after the monsoon, and continues till the onset of the next monsoon around mid-May. In the monsoon period, sea conditions in coastal areas are generally turbulent with strong winds. Most areas receive as much as 2.5 metres or more of rain during the monsoons, making field work extremely difficult or impossible. All marine exploration and surveying activity in Indian waters is, therefore, restricted to the 7 months of fair weather from October to May when a warm and humid tropical climate, with ambient temperatures of 30° to 40 °C, dominates the coastal areas. The sea is generally favourable, with calm to slight sea states during this period.

All Hi-Fix chains used in India except one have been of Type "A" which have no lane identification facilities. This has been mainly for reasons of economy. While this did not handicap surveys close to the coast, the lack of lane-identification in off-shore work has often caused the loss of many hours of surveying ships' valuable time in steaming to relock receivers. It is difficult to quantify such loss of time in order to justify procurement of type "B" chain at nearly double the cost of type "A".

By and large, all organisations have preferred the use of Hi-Fix in the marginally less accurate hyperbolic mode so as to permit the utilisation of chains by more than one unit at a time. This has, however, been possible only when the configuration of the coast permitted the siting of hyperbolic Hi-Fix stations suitable for good lattice cuts. Hence, hydrographic surveys in the Gulf of Kutch, Gulf of Cambay, the approaches to Hugli River, and in and around the major ports have been conducted using the Hi-Fix chain in the multi-user hyperbolic mode. Elsewhere, surveys along the straight coastlines have been mainly conducted with Hi-Fix in the single user two-range mode.

SELECTION OF STATIONS

In almost all cases, the Hi-Fix stations are sited close to the high water line as recommended by the manufacturer. In places other than major

harbours, access by road to these stations has been often non-existent and even impossible. Under these circumstances, the light and portable nature of Hi-Fix has greatly facilitated the landing and recovering of equipment from seaward. The logistics — diesel alternators and batteries — have, however, been heavy and cumbersome to transport. Thus the siting of Hi-Fix stations has, as far as possible, been close to sheltered landing places. Unfortunately many such sites are far from civilisation, and the personnel manning the stations have had to live in tents on inhospitable beaches frequented by snakes and crocodiles.

Access to Hi-Fix sites by road being difficult, the Hi-Fix stations and their personnel have had to rely for logistics supply and repair facilities on the boats of surveying ships or the helicopters on board such ships. In off-shore surveys, ship-borne helicopters have been the greatest asset, saving many man-hours and ship-days. In fact, to cover large areas with Hi-Fix, the helicopter has proved most necessary and even indispensable for logistics, quick repair calls and Base Lane Counts. Ships without helipads using Hi-Fix chains in such vast areas have employed a land-based helicopter successfully.

The availability of shore power supply has been an important factor in selection of sites. Even though Hi-Fix chains have portable diesel alternators for power supply, they have not been found dependable in a tropical climate for continuous operation of chains for periods up to 4 weeks at a time, over many months. The ships of the Hydrographic Department have, therefore, frequently managed to obtain the assistance of the Lighthouse Department for the provision of power supply from the generators installed in lighthouses. Thus, the sites selected for Hi-Fix stations have been close to lighthouses when possible. Such sites have also been useful for obtaining accommodation and logistic facilities for the personnel manning the stations.

In all cases, the Hi-Fix stations are connected to the nearest available geodetic stations by triangulation or trilateration. In some coastal regions this has been a prolonged operation spread over many weeks, as the geodetic stations have been on hill peaks well inland over difficult terrain. Extensive use of Tellurometer MRA 2/MRA 3 distance measuring equipment and Wild T2/T3 theodolites has been made to determine the positions expeditiously and accurately. Connection to the nearest geodetic stations has, therefore, been an important consideration in the selection of sites for Hi-Fix chains.

To illustrate the coverage of large areas by a Hi-Fix chain with minimum effort, maximum accuracy and meeting the special requirements of Indian waters, two examples of interest are given in the succeeding paragraphs.

Figure 2 shows the Hi-Fix coverage in the Gulf of Kutch and its approaches, utilising a single Hi-Fix chain in hyperbolic mode to delineate a channel for Very Large Crude Carriers (VLCCs) approaching an oil terminal with 22 metres draught. This chain was established by a surveying ship of the Hydrographic Department, initially with master station at M and slave stations at S1 and S2. This configuration provided good coverage of the Gulf between Longitudes 68°53′ E and 69°53′ E. When sounding

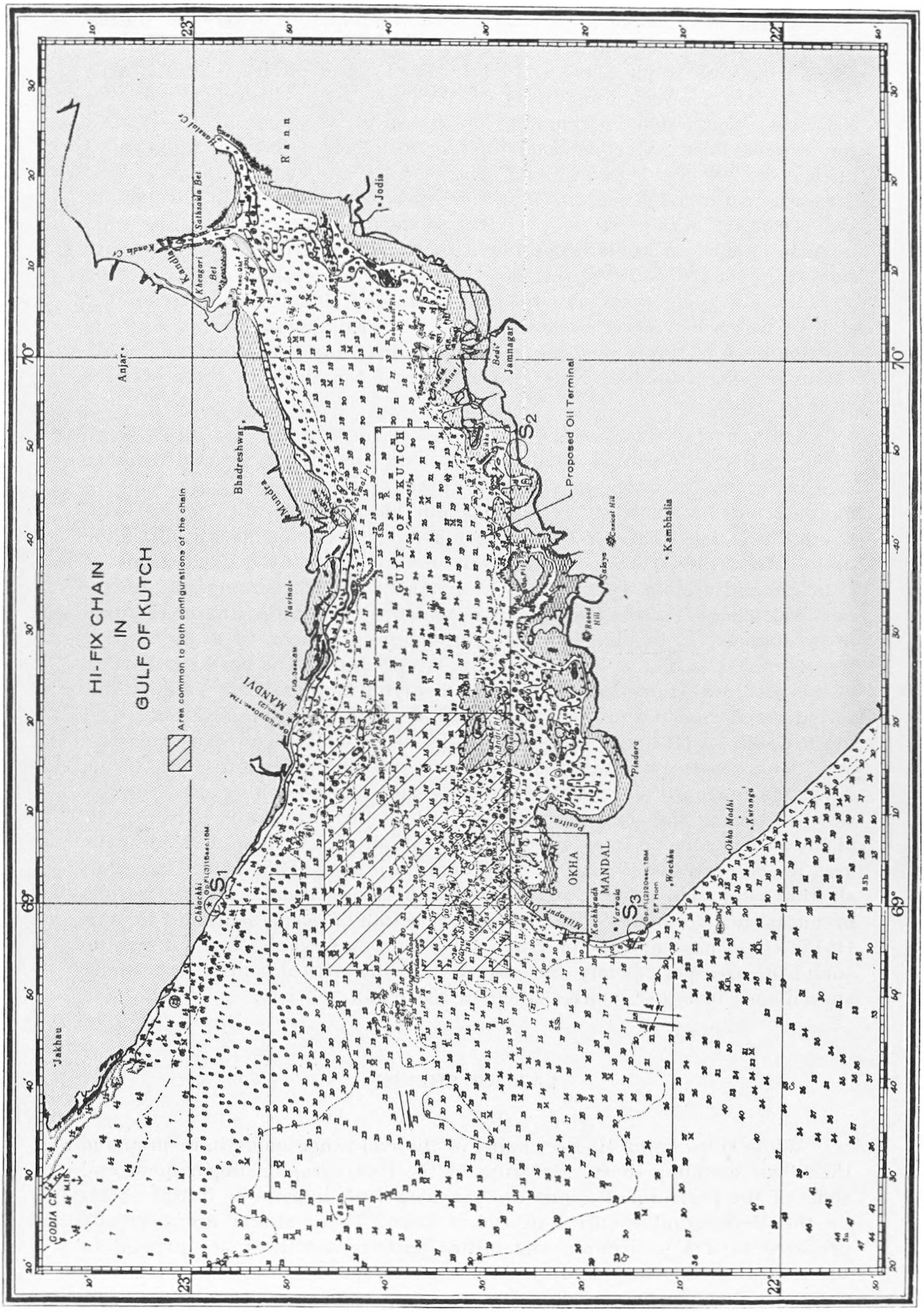
HI-FIX CHAIN
IN
GULF OF KUTCH
Area common to both configurations of the chain
GULF OF KUTCH
Proposed Oil Terminal
S1
S2
S3
OKHA
MANDAL
MANDVI
Mundra
Bhadreshwar
Anjar
Navinal
Jakhau
Chhachhi
Kandla
Jodia
Rann
Bedi
Jamnagar
Kambhalia
Salaya
Pindara
Okha Madhi
Kuranga
Varvala
Wachhu
Kachhiwadi
Positra
Sathsaida Bet
Khengeri Bet
GODIA CR.
70°
69°
23°
22°

FIG. 2.

in this area was completed, the slave station equipment at S1 was shifted to S3 to operate the chain in a new configuration from M, S2 and S3. In shifting this single slave station from S1, good coverage of the area was obtained between Longitudes 68°28′ E and 69°21′ E, which not only permitted completion of sounding of the entire channel for the VLCCs but also enabled extensive examination with side scanning sonar of a critical shallow area between Longitudes 68°53′ E and 69°21′ E. This critical area was covered by one or other configuration of the chain throughout the period of survey. It is pertinent to mention here the strong tidal streams of up to 5 knots encountered in the entire area, with an 8-metre tidal range during the spring-tide periods. On account of the strong streams, low lying coast and distance from the shore, the centre of the Gulf of Kutch had never been previously sounded thoroughly, as accurate positioning was rarely possible in these treacherous waters before Hi-Fix chains became available. Note also in figure 2 the siting of three stations close to lighthouses.

At the northern end of the East Coast of India, at the mouth of Hugli River, a Hi-Fix chain is used continuously round the year in similar configurations, in order to obtain a coverage over an area of about 40 nautical miles wide East-West and about 60 nautical miles long North-South. The Hugli River Survey Organisation is responsible for providing up-to-date depth data to river pilots taking critically loaded ships to Calcutta and Haldia Ports through this area. As the sand bars in the navigable channel of the Hugli change frequently, the entire area is required to be sounded at regular intervals throughout the year so as to provide weekly charts to pilots. Strong streams are present in the northern portion of this area, whilst open sea conditions, low lying land and bad visibility, due to industrial smoke and mist, make visual surveying exceedingly difficult in the South. A Hi-Fix chain has therefore been established to give coverage over the northern two-thirds of this area in one configuration. By shutting down the northern slave station of the chain and switching on a similar slave station in the southern portion of the area, the southern two-thirds of the area is covered in a second configuration. Thus, about a third of the area in the centre is covered by both configurations. This central area has shifting sand bars, some of which need to be sounded daily and the results broadcast to river pilots. The judicious selection of permanent sites for this Hi-Fix chain has enabled the Hugli River Survey Organisation not only to sound the area periodically, but also to keep the critical central area under surveillance in either configuration of the chain.

LATTICE SHEETS

While ships using Hi-Fix chains in the two-range mode have prepared their own sounding sheets, the ships of the Hydrographic Department and some of the port organisations are provided with hyperbolic lattice sheets by the Hydrographic Office in Dehra Dun. These sheets are normally prepared in TM projection, and lattice patterns on them are printed in red and green for easy identification. On average, two weeks are taken to

prepare a hyperbolic lattice sheet, and the ships programme their work accordingly.

CALIBRATION OF HI-FIX CHAINS

In siting Hi-Fix stations, the paths of propagation between master and slave stations and from stations to shipborne receivers are planned, as far as possible, over sea areas so as to reduce propagation errors. A speed of 299 650 000 metres/sec is used for computation of Hi-Fix lattices and has been found satisfactory. However, paths over the sea have not always been certain, especially over extensive drying areas such as in the Gulf of Kutch and the Gulf of Cambay, where tides rise and fall in a phenomenal range of 7 to 11 metres exposing extensive banks during low water periods. The chains have therefore been calibrated and monitored to determine errors due to changes in the path of propagation and other causes, so that errors in plotted positions are reduced to less than plottable quantities. As most of the surveying work using Hi-Fix chains covering large areas was on scales 1/25 000 or smaller, residual errors have not been plottable and have therefore been of only academic interest.

Calibration of chains has been mostly with simultaneously observed theodolite angles to the surveying vessel's mast from known shore stations. In some cases, direct distances from master or slave stations to the survey vessel were measured using Tellurometer MRA 2. The resulting computed position of the ship was compared to simultaneously recorded lane values of the receiver for correction of pattern settings. When possible, monitor stations are also established in the area of operation to observe the stability of the chain and establish corrections to pattern readings. For correction of patterns in the two-range mode, the electrical centre of the ship and locking constants for each pattern are determined by swinging the ship round the compass.

DIFFICULTIES EXPERIENCED IN OPERATION

The operation of Hi-Fix chains in Indian waters has not been entirely without difficulties, even when the chains were established and calibrated. The earth mat round the transmitting aerials, for instance, needs special attention in the tropics so as to maintain satisfactory aerial current and transmitter output. As the top layer of earth is generally dry in the tropics, the earth mat gives better performance if terminal spikes are driven deep into the soil and the area watered frequently to retain moisture and conductivity. In the ships it was found necessary to make earthing connections with copper wires and strips, running from the base of transmitter aerials over the ship's side to the hull below the waterline.

Over-heating of the equipment in the high ambient temperatures of the tropics has been a constant worry to the surveyors in the field. The blowers provided in units such as the receivers have often been found

inadequate, and it has been necessary to open the casings and provide additional cooling with external fans. Of course, in the smaller boats, the danger of salt water spray does not permit such exposure. Ashore at Hi-Fix stations, where the danger from salt water spray is small, the high dust content of fine sand in the atmosphere necessitates the guarding of Hi-Fix units from dust and keeping them in tents sheltered from the direct heat of the sun. This has to be specially taken into account during the warm months of April and May, when not only is there the scorching heat of the tropical sun but also many dust storms. The ingress of dust can easily cause electrical defects due to changes in the values of finely tuned electrical circuits.

Variation in the heating of the atmosphere across the propagation path in the tropics leads to a change in refractive index, which affects the speed of propagation. This in turn affects the repeatability of lane patterns, which have been observed at monitoring stations drifting up to 0.3 lane. This has to be specially borne in mind while examining areas on large scales to investigate shoals or search for underwater obstructions, with survey vessels running lines of small fractions of each lane.

Thunderstorms are also frequent on the Indian coasts during the period March to May preceding the monsoon season. The lightning during these thunderstorms can cause false triggering of the synchronisation between the various transmitters and receivers, causing spinning of lane counters and loss of a number of lanes at a time. Ships on coastal surveys have therefore had to steam many miles at times to re-lock receivers when operating chains that do not have lane identification.

The eastern coast of India experiences 6 to 10 tropical cyclones during April-June and October-December every year. Some of these cyclones cross over to the west coast as well. On receiving warning of such cyclones, it is prudent and customary to dismantle the chains and stow the gear in safe shelters.

Instability of radiated patterns has been frequently observed in Indian waters for 30 to 60 minutes prior to, and after, sunrise and sunset. Receivers have to be carefully and constantly watched during these periods.

The sockets of receiver aerials have often been troublesome, especially when aerial units have been accidentally exposed to salt water spray in small boats. Even minute particles of salt water on these sockets can cause electrical disturbance to the receiver. Due to partial earthing or short circuiting, this can lead to loss of lock. Similarly, any play in the delicate pins of plugs or sockets, caused by wear and tear over the years, is liable to introduce momentary erratic behaviour of lane counters due to make and break of contact. This is specially noticeable while sounding in small boats which roll or pitch appreciably in turbulent waters or swell.

Daily locking and checking of receivers in the field has been achieved by observation of simultaneous sextant angles leading to station pointer fixes when in sight of land with prominent marks. When this was not possible, generally due to poor visibility, tautly moored buoys and beacons, with previously determined position in Hi-Fix lanes, have been used to lock receivers in boats and ships. The positions of such buoys and beacons

are computed at both flood and ebb tide from shore observations. Receivers are locked or checked at the start and end of every sounding day and in-between whenever in doubt or in a suitable position. Dependence on good visibility and the necessity to steam long distances for the locking and checking of receivers have been an appreciable disadvantage in the operation of Hi-Fix in Indian waters.

In the tropical climate the attenuation of radio emissions is also found to be large. Consequently, the maximum usable range of Hi-Fix has been about 60-70 miles from shore stations. Though there has been no requirement to go further than this in hydrographic surveys of coastal areas, in the case of the Oil and Natural Gas Commission off-shore exploration could not be extended to areas such as the Bombay High due to the insufficient range of Hi-Fix. Shoran has therefore been used in lieu.

Communications between the sounding units and the parent ship as well as between the ship and Hi-Fix stations have often been a problem in the operation of Hi-Fix chains. Most communications have to be on medium and high frequencies due to the distances involved and attenuation of signal. Transmission of Hi-Fix frequencies interferes with such communications. Hence, communications have to be avoided in bands near Hi-Fix frequencies and their multiples. The Hi-Fix receivers have also to be kept well away from transmitters operating in the vicinity, which is a difficult task in the small boats carried in surveying ships.

PROBLEMS OF MAINTENANCE AND REPAIRS

Despite the day and age of jet travel, India is still a long distance from the United Kingdom where the manufacturer of Hi-Fix is located. Hence, all the organisations operating Hi-Fix chains in India have had to establish their own maintenance and repair facilities to be able to keep their chains operational over the years. With this in view, most organisations acquired Hi-Fix chains with recommended spares for 8,000 hours operation. These spares have indeed been invaluable to keep the chains operating. Importing of further spares into the country has, however, not been easy due to foreign exchange restrictions. It is unfortunate that despite the number of Hi-Fix chains operating in and around India there is no facility to obtain spares from sources closer to home.

Some organisations have had their personnel undergo training in maintenance with the manufacturer, but most have had to depend on their own electrical and electronic engineers to maintain the equipment with the help of literature provided by Decca. The Hydrographic Department trains its own personnel and has its own maintenance facilities; however it has had many difficulties in retaining the trained maintenance engineers as there is a great demand for such personnel in India and abroad. Most trained men are easily attracted to jobs outside the Hydrographic Department due to better wages.

The Aerial Matching Units and the portable generators have been the biggest source of repair problems in operating Hi-Fix. The performance of

the former is greatly dependent on an efficient earthmat and the operator's ability to finely tune the delicate control, which is prone to go off-tune. This needs to be watched carefully. Credit goes to the manufacturer of Hi-Fix, however, for producing an equipment which is generally reliable and not prone to major breakdowns. As long as spares have been available, repairs have not been difficult. Careful handling, especially in unsheltered landing places and in small boats, has perhaps been the most important item of preventive care and maintenance.

THE FUTURE

Hi-Fix has established itself in Indian waters as a reliable and productive Position Fixing Aid. It has been used successfully for precise survey control in hydrographic sounding, for coastlining with a receiver mounted on a jeep-type vehicle, for investigation of channels for obstructions with side scanning sonar, for fixing positions of isolated drying or awash rocks with helicopter hover when boat landing or sounding over them was not possible, for dredging control, in off-shore investigations for oil and gas, and for speed and manœuvering trials of newly built ships. More of our major ports and dredging organisations would like to acquire Hi-Fix or Sea-Fix chains if they could be certain of being able to maintain and repair the equipment on their own without difficulties. Over the years, the cost of Hi-Fix equipment and its maintenance, repairs and spares has escalated steeply, and this prevents most organisations from acquiring this dependable aid for precise position finding.

We in India are happy to note the further development of Hi-Fix into Hi-Fix 6 which, we understand, is of vastly improved design with tremendous flexibility in employment. It will have the facility to operate six station configurations, which will permit the simultaneous use of the chain in hyperbolic and two-range mode. It will be possible for a number of surveying units to utilise this chain simultaneously in hyperbolic mode, and some units in two-range mode. We hope that it will also provide improved coverage and longer range. Lane identification facilities are standard in Hi-Fix 6, and the manufacturer assures us of greater ease in maintenance and repairs due to its modular construction and use of many common printed-circuit boards in all its units. We look forward to using Hi-Fix 6 in Indian Waters.

ACKNOWLEDGEMENTS

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