

NIO'S EXPERIENCES IN DATAWELL WAVERIDER BUOYS

S. G. DIWAN, A. K. SURYAVANSHI & B. U. NAYAK
National Institute of Oceanography
Dona Paula, Goa-403 004

A B S T R A C T

The experiences gained by NIO, Goa since 1980 in the use of Datawell Waverider buoys under the long-term wave measurement programme at seven locations along the west and east coasts of India are briefly described in this paper. Information on planning of field work, mooring arrangement adopted, deployment and retrieval techniques, and the type of wave recording system used etc. has also been presented. Various operational problems associated with measuring and recording equipment, leading sometimes to loss of valuable wave data etc. have also been discussed. The damages occurred to waverider mooring system due to natural as well as man-made causes including remedial measures adopted have been briefly described. The experiences gained by NIO in this area, are expected to be extremely useful for better planning and success of future wave measurement programmes in India.

INTRODUCTION

National Institute of Oceanography (NIO), Goa began its comprehensive wave measurement programme in 1980. Fig. 1 indicates seven locations along the west and east coasts of India where Datawell waverider buoys were deployed as a part of this wave measurement programme. A considerable experience has been gained by NIO in regard to design of waverider moorings, deployment and retrieval techniques, operation of waverider buoys and wave recording equipment including processing of analog and digital wave data for engineering applications.

From Table I, it may be noted that a total of 20 waverider buoy deployments have been carried out at seven different sites, yielding 1690 buoy-days of operations at sea, out of maximum

possible of 1819 buoy-days. This works out to an in-service percentage of 92.91 and the average duration of each buoy deployment is 84.50 days ranging between 6 days off Daman at initial stages to 291 days at Bombay High.

A moored waverider buoy is capable of operating unattended for long durations of 10 to 18 months at sea depending upon whether the buoy is 70 cm or 90 cm size respectively. Waverider mooring lines were designed so as to withstand hazardous sea conditions for longer periods of time. Mooring components supplied by M/s. Datawell by were used in all moorings. Fig. 2 shows a typical waverider buoy mooring adopted at Bombay High.

The recording equipments were installed in a building located on the shore. Care is taken to see that the recording station was free from electrical disturbances and obstacles like tall buildings to facilitate better radio communication between the buoy and the wave recording units. When the waverider buoy was installed near the offshore platforms at Bombay High, the recording equipments were installed on the platform. Various instrumental and mooring problems encountered during the wave measurement programme at NIO using Datawell waverider buoys are briefly described in this paper.

HANDLING OF WAVERIDER MOORING

A locally available mechanised boat, usually a trawler having a derrick boom and a 2 tonne winch was usually selected for handling waverider buoys. The size of the boat varied from 12 meters to 16 meters. The same trawler was used for keeping a watch on the moored wave rider buoy when required particularly in the areas where the fishing activities were very high. Supply vessels were used for operations at Bombay High.

"Anchor last method" was adopted for the waverider buoy deployment. Before paying out the mooring gear, the boat was made to proceed towards the desired buoy location opposing the sea surface current/wind, whichever was dominant at the time of deployment of the waverider buoy. The buoy was first dropped in sea from the stern of the boat with the boat moving at about 2 knot speed. The connected mooring was paid out manually under moderate tension. Ultimately, the anchor was dropped from the stern of the boat. During recovery operation, the waverider buoy was first hauled up and kept on the deck of the boat. Then the upper slack part of the mooring including the rubber cord and the floating polypropylene rope were manually pulled up on the deck. Finally winch was operated for hauling up the dead weights and the sub-surface buoys on the deck. Proper manoeuvring of the boat was very important particularly when the sea was rough for safe retrieval of the waverider buoy and its mooring.

WAVE RECEIVING/RECORDING STATION

The Datawell Waverider Receiver (WAREP) in conjunction with Digital Magnetic Tape Recorder (DIMA) was used to receive and record the wave data transmitted by the waverider buoy (Fig. 2). An omnidirectional antenna for the WAREP receiver was installed at a convenient height. The analog wave records were obtained on 10 cm wide chart paper used in the WAREP while digital data were recorded on verbatim 300 H type digital cassette in DIMA. Both these units were generally operated on 220 volts A. C. mains supply and on failure of the mains supply, the units were set to automatically switch on to the external standby 12 volt, 80 AH lead acid storage battery. Whenever these recording equipment were used in remote coastal villages where frequent power failures used to occur for extended period of time, a portable 500 watt AC/DC petrol generator was used to charge the batteries and the recording equipment were operated on these batteries.

DATA PROCESSING TECHNIQUES

The WAREP was operated in program mode to record 20 minute wave data at every 3 hours continuously. The analog wave records were analysed using Tucker's method to determine the significant wave height " H_s " and zero crossing wave periods " T_z ". The DIMA unit interfaced with WAREP in program mode records digitised data on cassettes for every 0.5 seconds interval. These data were further transferred on 1/2" computer compatible magnetic tapes using Memodyne Tape Reader 3122 ABVT interfaced to Kennedy Incremental Magnetic Tape Recorder 1600/360 (Fig. 2). For spectral analysis of the digitised time series data on cassettes a software package NEPTUN was used on DEC-10 computer. For each 20 minute wave records digitized at 0.5 seconds interval, this computer programme takes 2048 data points for analysis. This program carries out the necessary checks on both raw and computed data to have a control over the quality of the data. The raw data are subjected to various checks on spikes, steepness, constant level of signal etc. The program computes the frequency spectrum of the time series using Fast Fouriers Transform.

SOME PROBLEMS FACED IN WAVE MEASUREMENT PROGRAMME

The wave data collection programme was sometimes seriously affected due to various reasons such as electronic failure of waverider buoy or recording equipment or drifting or loss of the waverider buoy from its location etc. Some of the problems faced by NIO in its wave measurement programme are summarised below:

Instrumental Failures

On one occasion the flash light unit in the waverider buoy failed due to short circuit in H-F autotransformer mounted in the flash tube assembly within the roof hatch glass. Also in the same buoy, the pcb responsible for R-F transmission failed due to leakage of sea water through the damaged O-ring between the roof hatch sealing plate and its mating flange on the waverider hull. The buoy was reused after replacing the O-ring, defective flash tube assembly and the top pcb. In one instance, a fishing vessel collided with the waverider buoy and the accelerometer suspension assembly was broken rendering the buoy irreparable.

During the wave measurement off Kakinada a few consecutive wave records showed variation of zero line with time periods of 40 seconds which was attributed to spinning of the waverider buoy induced due to the surface disturbances caused by a vessel used for fixing the position of the buoy station. This disturbance disappeared after about 24 hours when the disturbed fluid, surrounding the accelerometer platform came to the original state. Similar zero line variations were also noticed at other places which are suspected to have been caused due to watchkeeping boat approaching very near to the buoy.

The analog wave recording unit WAREP was found to be most reliable for the Indian climate. Very few problems were faced during the operations of these units in the past 5 years. In one instance the rectifier diode of the 24 volt power supply was found open due to power fluctuations. In two instances supply pcb which converts the DC voltage to 220 volts AC for the operation of chart recorder unit and programming clock has to be changed during the field operation. Pen movement of the recorder in the WAREP totally stopped as the pen holder arm of the recorder assembly was jammed. This was due to mishandling of the recorder pen while filling the ink and also during insertion of new labyrinth pens in the pen holder. This was rectified after removing the bend in the pen arm of the pen holder assembly.

The digital data recording unit DIMA gave frequent problems in field. In three instances recorder deck drive pcb-B had to be replaced while in two instances digital clock pcb-E was changed. Also in one DIMA unit the recorder deck was replaced as the sensitivity of the recorder head reduced drastically.

Mechanical Faults and Failures in the Mooring System

Mechanical failures in the mooring was equally responsible for the loss of data leading sometime to loss of waverider buoys and its mooring hardwares during the wave data

collection programmes. Some of these failures encountered during this work are outlined below.

(i) Rubber cord pulling out of its end fittings

This type of failure had occurred a couple of times during the recovery of waverider buoy and its mooring using offshore supply vessels at Bombay High. The waverider buoy was hauled up on the boat deck while its mooring anchor was still on the sea bed. The boat used for recovery operation started drifting away from the buoy station due to strong surface currents prevailing in the area during this operation. The supply vessel could not be manoeuvred properly and this caused the rubber cord to stretch beyond its tolerance limit. This led to the rubber cord pulling out from its upper stainless steel end fitting connected to the waverider buoy stabilising chain, causing the loss of the full moorings.

In the event of loosing the rubber cord and the sub-surface floats, attempts were made to recover the submerged part of the mooring with various methods. In most cases bottom trawling at the waverider buoy location using fishing nets with weights tied to their bottom ends was found to be more successful than trawling with grapnel hooks.

(ii) Damaged rubber cord

A few mooring failures occurred as the rubber cord got cut and the buoy drifted freely in the sea. These failures were attributed to the entangling of the drifting fishing nets with the waverider mooring and interference of passing boats/vessels. Prolonged excessive tension in the rubber cord seems to cause this failure. In other cases the rubber cords were found cut presumably by the fishermen while separating the fishing nets entangled with the waverider buoy mooring, thus causing the waverider buoy to drift freely in sea. Fig. 3 shows the photograph of a damaged rubber cord. The buoy deployed off Umbergaon drifted to a rocky shore at about 250 km north from the anchored position. Later this buoy was traced and recovered from a local fishermen in Baroch district of Gujarat. The Cunnifer U-eye on the waverider bottom provided for connecting the stainless steel stabilising chain was found broken (Fig. 4). This seemed to have occurred due to mis-handling of the buoy by the fishermen. The upper aerial spring was also found bent.

Whenever the buoy was found to have drifted from the moored location, extensive search operation was carried out all along the nearby coast with the aid of multi-channel direction finder OAR model FR-206, which has fairly good signal range for

tracking the buoy in sea. Most of the search operations were undertaken during night with a few boats moving in different directions from the buoy location. The flash light of the waverider buoy, many a times helped in tracing the buoy. In wave measurements off Kakinada, search operation at sea was carried out with a WAREP receiver installed on the boat as it has high sensitivity for receiving the signal. In most of the cases the waverider buoys were recovered either from nearby shore or from the offshore areas. Sometimes, the wide publicity given about the lost waverider buoy in the nearby fishing villages helped in tracing the adrift buoys.

(iii) Failures due to passing boats/vessels knocking the buoys

The waverider buoy moored in the Mandovi estuary at Goa is suspected to have been knocked off by a fishing vessel damaging the accelerometer suspension assembly beyond repairs. On recovery of the buoy it was found that the rubber fender around the buoy was missing and a severe dent on the hull surface was also seen. The triangle recommended by M/s. Datawell to safeguard the buoy against hazards likely to cause by passing vessels/boats was not used as it was not available at that time.

(iv) Sea water in the whip antenna base socket

In the waverider buoy deployed off Umbergaon the splashing sea water was once collected in the whip antenna base socket. This was found to be due to the damaged aerial socket sealing washers below the top aerial, but this resulted in poor signal transmission from the waverider buoy. The buoy was recovered and the aerial base socket was dried up. The same buoy was redeployed with new socket sealing washers.

(v) Partial submergence of the waverider buoy

During the periods of heavy flood water discharge in the Godavari basin causing strong currents at the buoy location off Kakinada, the waverider buoy used to submerge frequently. In a few occasions plant bushes carried by river water got entangled with mooring line resulting in high drag on the buoy and subsequently submerging it partially. The free floating ability of the buoy was restored after separating the entangled bushes from the waverider buoy mooring. On a few occasions, heavy growth of algae on the waverider surface and huge colony of barnacles grown on the subsurface floats (Fig. 5) were observed off Kakinada. Such growth was also responsible for partial submergence of the buoy during periods of strong

currents.

(vi) Marine corrosion

Severe type of crevice and pitting corrosion was found on the non-magnetic 316 stainless steel hull of the buoys deployed at Bombay High and off Uran. The attack of crevice corrosion was found on two major parts of the waverider buoys as given below.

(a) The area of the roof hatch sealing plate and its mating flange area on the buoy hull.

(b) The O-ring grooves for the seals between the flash light glass and the stainless steel sealing plates of the roof hatch.

The corrosion described as in (a) above, was more dominant because of frequent opening of the roof hatch cover for servicing, inspecting or connecting and disconnecting of the batteries of the waverider buoy. But the effect of crevice corrosion was kept at very low rate by the normal practice of liberally smearing silicone grease on all mechanical contact points of the joints prior to reassembly.

Pitting due to severe crevice corrosion were found on both non-magnetic 316 stainless steel buoys deployed off Uran and at Bombay High. A continuous exposure in the sea environment for four months was sufficient to cause severe pitting on the waverider buoy off Uran. These pitted holes were normally scallop-shaped and some of them have penetrated 50% or more of the hull thickness. Practically no traces of pitting corrosion was seen on 90-10 copper-nickel alloy buoys even after their prolonged duration of exposure to the same sea environment. Fig. 6 shows the photographic view of the pitting corrosion on waverider buoy hulls.

The 316 stainless steel D-type shackle used in the mooring line of a buoy deployed off Uran was found severely pitted (Refer Fig. 7). Corrosion attacks were generally around the threaded part of the shackle bolt and in the crevices formed between the bolt head and body of the shackle. The corrosion on 316 stainless steel waverider hull was suspected to have occurred due to penetration of sea water under the pinholes in the painted hull surface and also due to growth of barnacles over it, which properly initiated crevice corrosion leading further to severe pitting.

PROBLEMS IN DATA PROCESSING EQUIPMENT

The DIMA records digital wave data on cassettes as 12 bit

binary word. When this cassette is run on Memodyne Tape Reader 3122 ABVT interfaced to Kennedy Incremental Tape Recorder, 12 bit word is modified to 16 bit word in which 4 extra non-significant bits are added. This 16 bit data word is written on the 1/2" magnetic tape by Kennedy Incremental Tape Recorder. While using this data for computer analysis the 4 extra bits have to be removed so as to retrieve the original 12 bit wave data word. This logical problem was solved on TDC 316 mini computer as explained in Fig. 8. The same logic was applied on DEC 10 computer to convert the raw data of 16 bit word length to desired 12 bit wave data. After solving this problem, the collected wave data could be analysed using software program NEPTUN on DEC-10 computer.

About 40% of the recorded digital data could not be analysed as the magnetisation level of the cassette records was dropping down during the recording period of the cassette to a level which could not be sensed by the Memodyne Tape Reader head. Hence, some of the cassettes could be analysed only for part of the first recorded length. This was thought to be the instrumental problem. The wave recording tests using DIMA interfaced to WAREP were conducted in the laboratory on three DIMA units. It was observed that when DIMA is operated in the field recording stations, the magnetisation level of the cassette reduced with time. High humidity and temperature, salt spray and dust carried by winds were suspected to be the main causes for this improper performance of the DIMA.

CONCLUSIONS AND DISCUSSION

The success of long-term wave data collection and analysis using, Datawell waverider buoy depends upon proper functioning of the various electronic equipment, safe mooring of the waverider buoy and its successful operation at sea. Based on the experiences gained in wave measurement programmes at NIO, the following conclusions are drawn:

(1) The small fishing trawlers can be successfully used for deployment and retrieval of waverider buoys in the coastal waters. Offshore supply vessels are found to be very inconvenient for recovery operations as they are poorly equipped and they could not be manoeuvred properly.

(2) Continuous watchkeeping on the waverider buoy reduces the chances of loss of the waverider buoy or their drifting from the moored location particularly at high fishing zone.

(3) Regular checking and redeployment of the mooring at an interval of 6 to 9 months ensures long-term wave data collection with minimum of interruptions. Replacement of the whole mooring at the time of redeployment is desirable to avoid failure of the mooring due to corrosion fatigue.

(4) Scrap ship chain links are most suitable for using as anchor weights as they are cheap and easy to handle from small boats.

(5) The waverider buoy made up of 90-10 copper nickel alloy (Cunnifer) hull is found to be more resistant against marine corrosion even in polluted waters off Bombay and Uran.

ACKNOWLEDGEMENT

The authors are grateful to Dr. H.N. Siddiquie, Director, NTO for his keen interest and encouragement.

REFERENCES

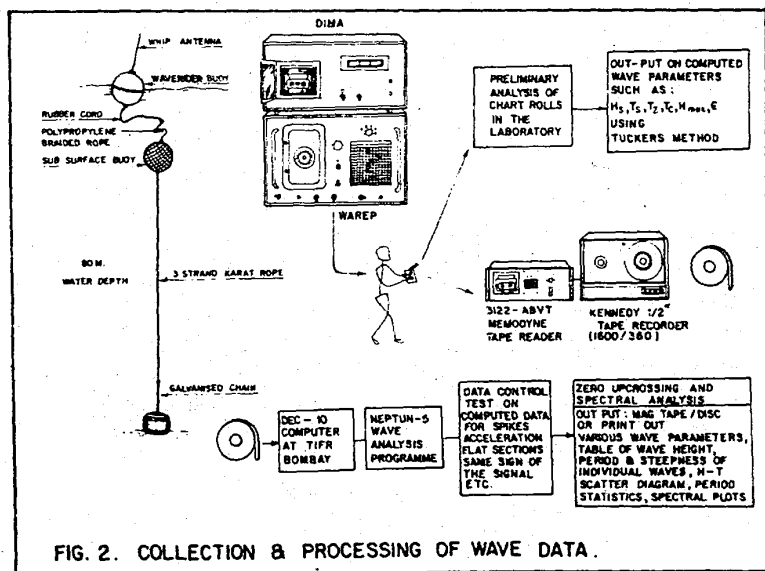
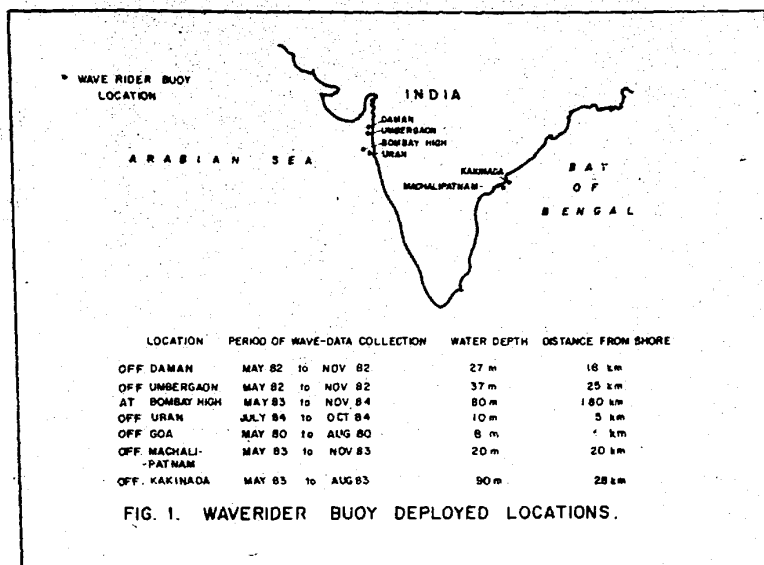
1. Humphery, J. D. (1975). Waverider moorings and their modification at I.O.S. Society for underwater technology, Proceeding October, 42-46.
2. Humphery, J. D. (1982). Operational Experiences with waverider buoy and their moorings, I. O. S. Report No. 145.
3. Gerritzen, P. L. J. G. A. Van Breugel (1979). Operation and Service manual for Waverider.

TABLE 1

Waverider buoy performance off the east and west coasts of India

| S.No. | Location of waverider buoys | Period of study | | No. of buoy days of study possible "X" | Actual no. of buoy days on site. "Y" | Y X % | No. of deployments. | Adrift |
|-------|-----------------------------|-----------------|-----------|---|---|-------------------|---------------------|------------|
| | | Start | Finish | | | | | |
| 1. | Off Goa ¹ | 22 May 80 | 2 Aug 81 | 70 | 70 | 100 | 1 | N11 |
| 2. | Off Daman | 14 May 82 | 26 Nov 82 | 197 | 172 | 87.3 | 5 | 4 |
| 3. | Off Umbergaon ² | 10 Jun 82 | 23 Nov 82 | 167 | 113 | 67.6 | 3 | 1 |
| 4. | Off Machilli- patnam. | 9 May 83 | 18 Dec 83 | 224 | 224 | 100 | 2 | N11 |
| 5. | Off Kakinada ³ | 14 May 83 | 1 Sep 84 | 477 | 461 | 96.6 | 5 | 3 |
| 6. | At Bombay High | 22 May 83 | 12 Dec 84 | 571 | 537 | 94.05 | 3 | N11 |
| 7. | Off Uran | 26 June 84 | 16 Oct 84 | 113 | 113 | 100 | 1 | N11 |
| | | | | Total 1819 days | Total 1690 days | Average 92.91% | Total 20 | Total 8 |

- Note:** 1. Due to failure of accelerometer, data could be collected for only 51 days.
 2. Second redeployment delayed due to non-availability of Waverider buoy.
 3. Buoy lost on 1st September 84 and is not yet traced.



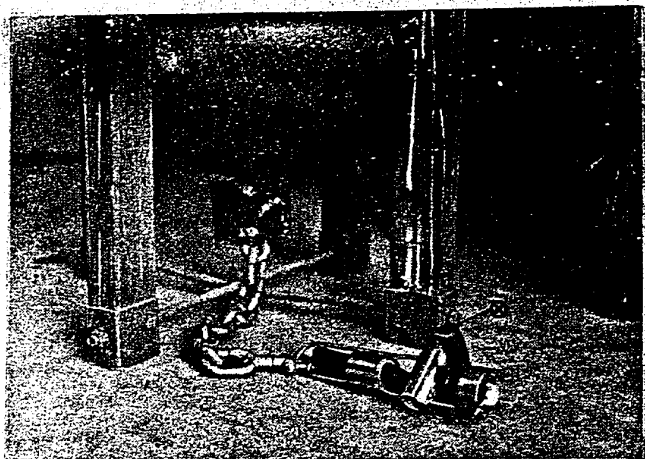


FIG. 3 ⊗ - BROKEN RUBBER CORD END



FIG. 4 ⊗ - BROKEN U-EYE FOR STABILIZING CHAIN.



FIG. 5 BARNACLE GROWTH ON
SUBSURFACE BUOY

AND

ALGAE GROWTH ON
WAVERIDER HULL

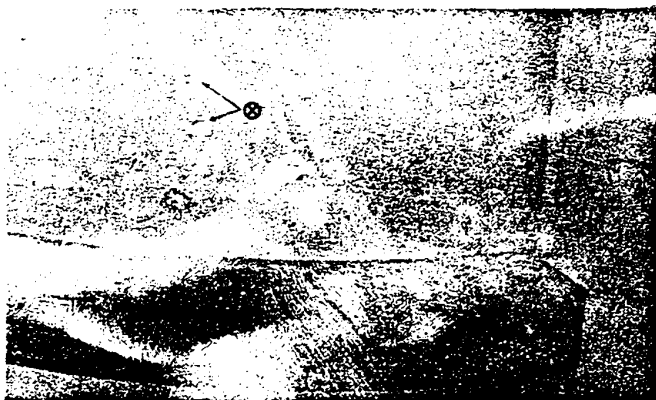


FIG. 6 ⊗-CORROSION PITS ON WAVERIDER HULL

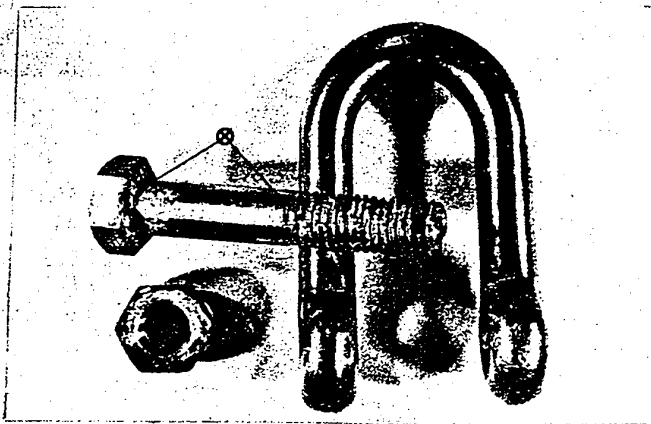


FIG. 7 - CORROSION OF 316 S.S. SHACKLE

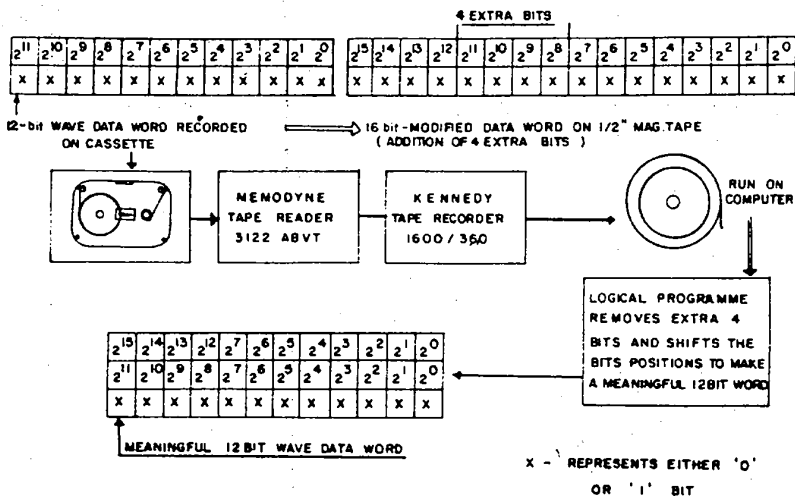


FIG. 8 METHOD OF 12 BIT DATA WORD RECOVERY.