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# A NEW SEISMOLOGICAL STATION AT MAITRI, ANTARCTICA

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## Abstract

A Seismological Station (code named MAIT) equipped with a matched 3-component short period digital and a short period vertical analog seismographs was commissioned ai Maitri, the Indian Antarctica base station. The station became operational from 26th Jan, 1998. A noise survey for selecting a suitable site and feasibility study with the aim of operation of Broad-band seismographs at the station was carried out earlier during the Antarctica summer, in Jan-Feb, 1997. The normal background noise due to artificial and natural sources was found to be very low. However, a very high level of noise was observed due to heavy winds during the blizzards which rage the icy continent quite often. A thermally insulated vault has been specifically designed and buried underground as the Broad-Band seismographs are very sensitive to temperature and pressure variations. The vault has been further provided with an electronic device which maintains inside temperature at 15±0.5°C. The recording is done in continuous mode with 24 bit digitizer @ sampling rate of 50 samples per seconds. An internal GPS clock with the data acquisition system provides accurate time. The digital and analog data is analyzed daily and the phase data is e-mailed to Hyderabad weekly. The complete digital data is archived on DAT tapes. In this article the details of the feasibility study, instrument details & their calibration, and details of specially designed seismometer vault have been described. The station is in continuous operation.

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/. *Participated in XV! and XVII IAE (Summer)*
2. *Participant in XVII IAE (Wintering, 15th WOT)*
3. *Planned and supervised the program.*

## Introduction

With the objective of installation of a permanent state-of-the-art digital Broad-band seismological station at Maitri, the Indian Antarctica base station, a reconnaissance for feasibility and site selection was carried out during the XVIth Indian Scientific Expedition to Antarctica in Jan-Feb, 1997. The aim of the station is to monitor earthquakes in and around Antarctica, the region with very low level of seismic activity, and overall monitoring of teleseismic events. This station would be specifically useful in the epicentral locations in the Indian Ocean, south of Asia and Africa, Presently only a three component short period digital Seismic system has been commissioned. A short period vertical analog seismograph is also being operated simultaneously.

The station was formally inaugurated by Mr. Alexander Kandratiey, the leader of 42nd Russian Antarctica Expedition to NOVO base station, who was the 'guest-of-honour' on the occasion of the India's Republic Day celebrations at the Maitri station on 26th January, 1998 (Picture-1 ).

The station coordinates are

| | | |
|---|---|---|
| Latitude | : | 70°45.94' South Longitude 11°44.13' East |
| Elevation | : | 115 meters |
| Station Code | : | MAIT |

The location of the station in the 'MAITRI complex' is shown in Fig. 2.

## Seismic Status

The Antarctica is seismically very quiet. Its surroundings are also less active. Due to the absence of any habitation no information was available about the actual seismic status of the continent. The operation of a seismological stations in Antarctica are very useful as they provide valuable control on global hypo-central determinations especially of the earthquakes in higher latitudes in the southern hemisphere. Antarctica's exposed bedrock amounts to less that 2% of its surface which is located along the margins of the continent. This puts a restriction on the location of the seismic stations as operation of stations in the ice covered areas is difficult during the winter months. Even most of the base stations of various countries are located along the exposed lands. However USA is maintaining SPA station at the South Pole where ice cover is about 2900 meters thick.

A temporary station in Antarctica was operated as early as 1902-1903 at Scott-Base. Later on, some more stations were operated intermittently by various countries between 1940-52. During the International Geophysical Year (1957), 4 stations were operated at MIR, SBA, WILKES and ADELIE (Richter, 1958) Two WWSSN stations are in operation from 1963-64 at SBA and SPA. Subsequently many countries have installed seismographs at their base stations in Antarctica. The locations of which are shown in Fig. 3. (after Kaminuma 1992). Due to difficult environmental and operating conditions continuous operation of the station is rather difficult and many stations have a very high down-time as the repairs are not possible. Perhaps for this reason only, the first hypocentre in the region could be instrumentally located by NEIS as late as 12th January 1995 when an event of magnitude 4.4 occurred at 62°S & 44.1°W.

This event was reported by 14 stations (I.S.C). Some seismic activity has been observed in Antarctica after the establishment of many seismological stations by various countries. (Kaminuma and Chadha, 1997). Total 10 events with magnitudes (5.0 have been located during the last three decades out of which 6 have occurred in Wilke's land, in south-eastern Antarctica along the continental shelf. An earthquake of magnitude 5.1 occurred off Terra Nova Bay in Ross Sea on 31, May, 1995 (I.S.C). All these events are plotted in fig.3.

With the addition of more stations and their uninterrupted operation, many more of small magnitude events may be located which may provide valuable information about tectonic zones below the ice cover as it not possible to study them directly. Thus, there is a great need of addition of more stations. Accordingly, the present seismological station has been started at Maitri, the Indian Base Station in Antarctica.

The present day technological advancement has made possible setting up of Broad-band Digital Seismographs in Antarctica conditions for obtaining complete frequency spectrum of various seismic phases from wide range of sources and analysis of waveform data on computers. Presently over 10 Broad-band Digital Seismographs are under operation in Antarctica continent. The 'MAIT' station will also be upgraded shortly by Broad-band seismographs of model CMG-3 ESP manufactured by M/S Guralp-Systems Ltd., U.K.

## Feasibility Study

An analog seismograph was operated for 45 days during Jan-Feb, 1997 at several sites in the Maitri complex, the Indian Base station at Antarctica, with a purpose of selecting a suitable site, with minimum noise level. A short period vertical component seismometer (S-13 of Teledyne-Geotech USA) was operated and the recording was done on chart paper with ink on RV 320 B Portacorder of the same company). Different filter settings were tried to understand qualitatively the background noise level. The records were obtained by operating the seismometer in shallow pits and under normal Antarctica summer weather conditions, at a gain of 78db and filter settings of 0.2 to 0.5 Hz. During the operation, 23 events were recorded out of which 20 were reported by NEIS. Locations of their epicenters are shown in Fig.4. A seismogram for an earthquake of magnitude 6.4 on Jan, 23, 1997 from southern Bolivia at a distance of 7200 Km from Maitri and an earthquake of magnitude 4.7 on Feb 6, 1997 at a distance of 2000 Km from Maitri, from a region south of South Africa in the Indian Ocean are also shown in Fig.5. This was the nearest event recorded during the period of test operation. From the records it was observed that the normal background noise due to natural and artificial sources was quite low. This suggested the possibility of operation of analog records at a high gain of 78 dB to 84 dB which is equivalent to a maximum magnification of 200 K at 1 Hz. Fig.5 also includes the record of a blizzard which occurred on Feb 6, 1997 and lasted for about eight hours. A high level of noise was observed during the blizzards as evident from the lower portion of the record (Fig.5). To reduce the noise during blizzards it was considered necessary to avoid the installation of sensors in Portacabin which is commonly used in Antarctica, as the wind pressure would shake the cabin and increase the noise level exorbitantly. It was, therefore, decided to make an underground vault to minimize the wind noise. Instead, in a way, a Porta cabin has been buried underground.

## Geologic Setting

The Indian Antarctica Base Station, Maitri is located in a region known as Dronning Maud Land which covers roughly Longitudes from 10° W to 40° E at an average Latitude of about 70° S. The bed rock is of pre-Cambrian gneiss's which is highly fragmented at the top. Locally the area is known as Schirmacher Oasis. There are number of lakes nearby the station. A lake in the immediate vicinity of the Maitri is known as Zub lake but the same has been now named as Priyadarshini lake. This lake is not causing any noticeable seismic noise as it is very shallow and is frozen most of the time.

## Seismometer Vault

Based on the initial design prepared at NGRI, a thermally insulated cabin was finalised and fabricated by the Research and Development Engineers of the Defence Research and Development Organisation at Pune. The inside dimensions of the vault are lm (width) x 2 m (length) x 2m (depth). The schematic of the cabin is shown in Fig.6. The material used for- building the side panels are 125 mm thick of special heat proof, synthetic material which is commonly used for the construction of structures in Antarctica. This underground vault also helps in providing a thermally stable environment, free from atmospheric fluctuations. A deeper vault would have provided better controlled environment especially to the Broad-band seismometers which are highly sensitive to temperature and pressure fluctuations. The striking of somewhat compact bedrock and difficult logistics in Antarctica in digging in hard rock limited the depth of the vault.

Bulldozers available at the Maitri station were utilized to facilitate digging in the hard-rock i.e. the Archean gneiss's (fragmented at the surface), the exposed bed rock at Maitri. To dig a pit to a depth of over 2 Mts., first a very large cavity was made to facilitate the operation of the Bull- dozers, Fig.7 show the digging operation. At the bottom of the pit a platform of prefabricated cement concrete blocks of 100 mm thickness was anchored to the Bed rock. The vault structure was erected on the platform. All the joints of the cabin were sealed to make it airtight. A complete view of the vault in position is shown in Fig. 8. The space around the vault has been filled tightly with boulders and sand. A view of the buried seismometer vault after filling of the surrounding space is shown in Fig 9. The vault has been completely buried and is covered further with a canvas sheet.

## Short Period Seismographs

A three component short period digital seismograph system has been now operational at Maitri. The inside view of the seismometer vault with the seismometers under operation is shown in fig. 10. A vertical component analog seismograph is also under operation for which the recording is done on RV 320 B Portacorder by Teledyne-Geotech.

Following are the details of the system:

| | | |
|---|---|---|
| Seismometers Make | : | Teledyne-Geotech (now Teledyne-Browning), USA |
| Model | : | S -13 |
| Pendulum Period | : | TO = 1.0 sec |
| Damping | : | 1 = 0.67 |
| Data Acquisition System | : | Model : 72 A-08 Reftek, USA |
| Digitizer | : | 24 bit |
| Sensitivity | : | 1.907 m v/counts |
| Sampling rate | : | 50 samples per second |
| Recording mode | : | Continuous |
| Hard Disk | : | 1 GB |
| Data analysis . | : | Daily |
| Data Retrieval & Archive | : | On DAT tapes. |

Recording is done in a separate room known as Tirumala hut by carrying the signals through cables of about 25 Mts. length. Fig. 11 gives an inside view of the recording room.

## Calibration of the Digital Seismograph

All the instruments were first installed, necessary adjustments made and performance was checked at Hyderabad prior to shipment. The calibration of the digital seismographs have been checked by in situ excitation of the auxiliary calibration coil with signals of frequencies of 0.1, 1, 2, 5, & 10 Hz. A portable calibration unit PS-200 by M/S Teledyne-Geotech was used for calibration of the seismometers simultaneously after adjusting the free periods of the three seismometers to 1 Hz. The system response of the each seismometer was matched for a damping of 1 =0.67 and the system response for the each component for a constant current of 7ma to the calibration coil for different frequencies is shown in Fig 12, The response of the three seismometers is well matched. The computed displacement response curve for the vertical component seismometer is given in Fig. 13. These curves are used for obtaining ground amplitudes for earthquake magnitude determinations.

## Data Analysis

The digital and analog records are analyzed every day. The phase data is sent every week to NGRI, Hyderabad by email. It is planned to send data to I.S.C. (U.K.) for inclusion in the final hypo-central determinations. The NEIS epicentral determinations are routinely emailed from Hyderabad to Maitri to facilitate and check the analysis of earthquake phases.

## Future Plan

As per the original plan the short period seismometers would be upgraded with Broad-Band seismometers of M/S Guralp CMG 3 during the next expedition. The procurement of the equipment is under process. For sending the Phase data of Maitri station to NEIS for inclusion in global hypo-central determinations through email is being taken up.. Preliminary Determination of Epicentres (PDE) will be directly received at Maitri through Internet.

## Acknowledgements

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Fig.1 Inauguration of the seismological observatory by Mr.Alexander kandratiey, Leader of the Russian Antarctic Expedition to NOVO base station

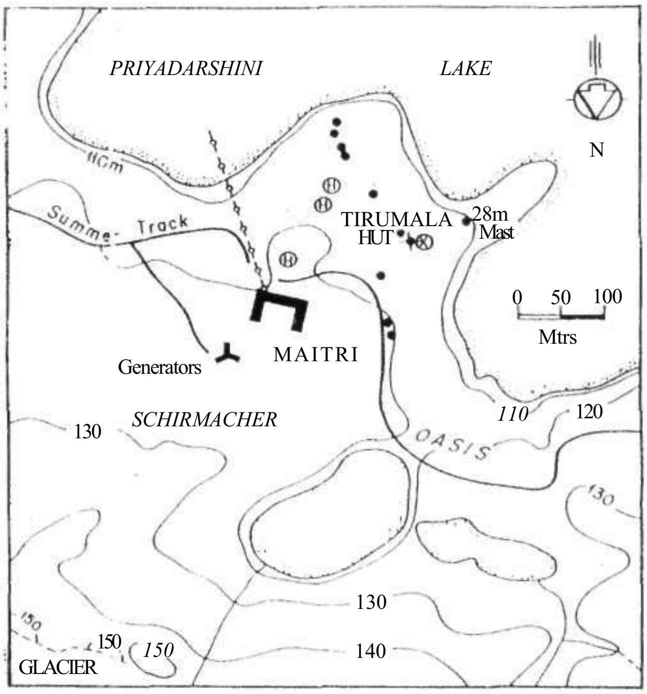


Fig. 2 A sketch of the Maitri complex with location of the Seismological station shown ⓧ Tirumala hut where continuous recording is done is also marked

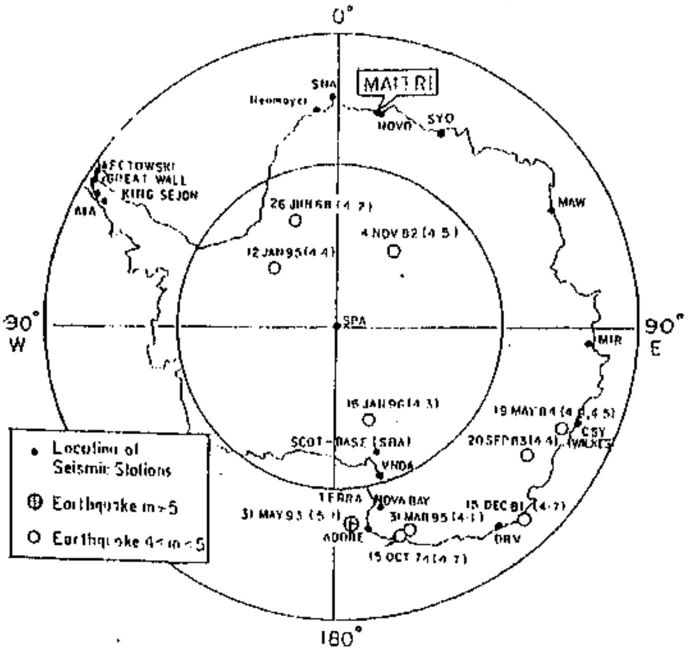


Fig 3. Location of Seismological station in Antarctica (•). Earthquakes observed during the last 3 decades are also shown (o). An earthquake of mag.5.1 occurred on May 31, 1993 off Terra Noava Bay (').

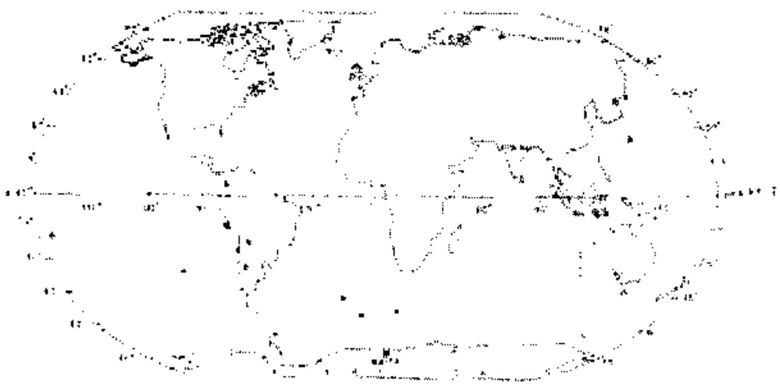

Fig. 4 Show the location of earthquake events (from NEIS) recorded during the 45 days operation of an analog seismometer during Jan - Feb. 1997

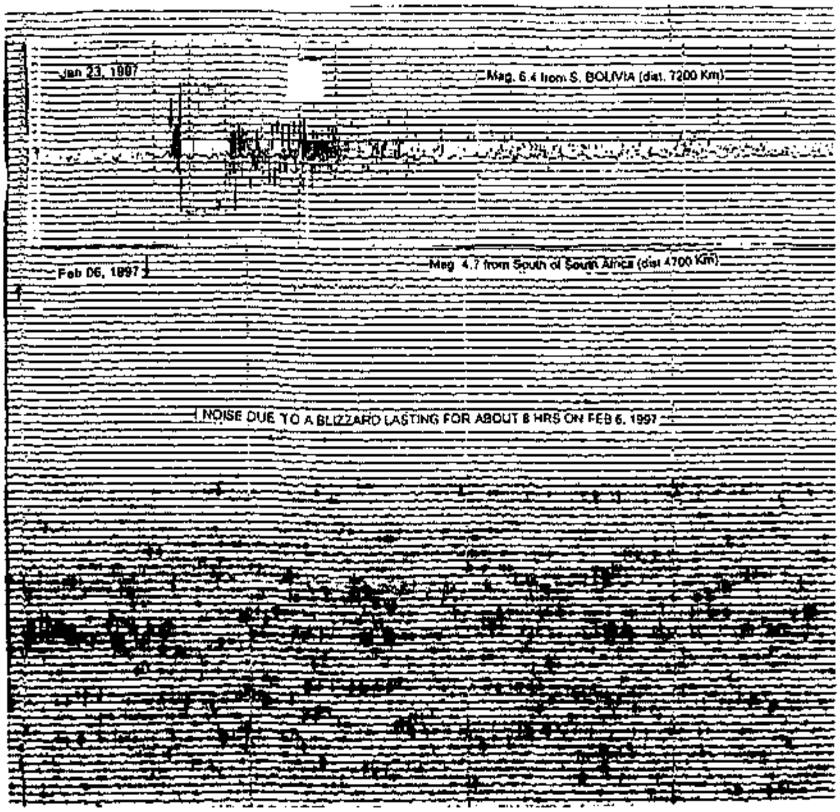


Fig. 4
Shows sample of records for an earthquake of M 6.4 from S. Bolivia at a distance of 7200 Km on Jan, 23, 1997 and of M 4.7 from south of Africa at a distance of 2000 Km on Feb. 6, 1997. The bottom portion of the figure

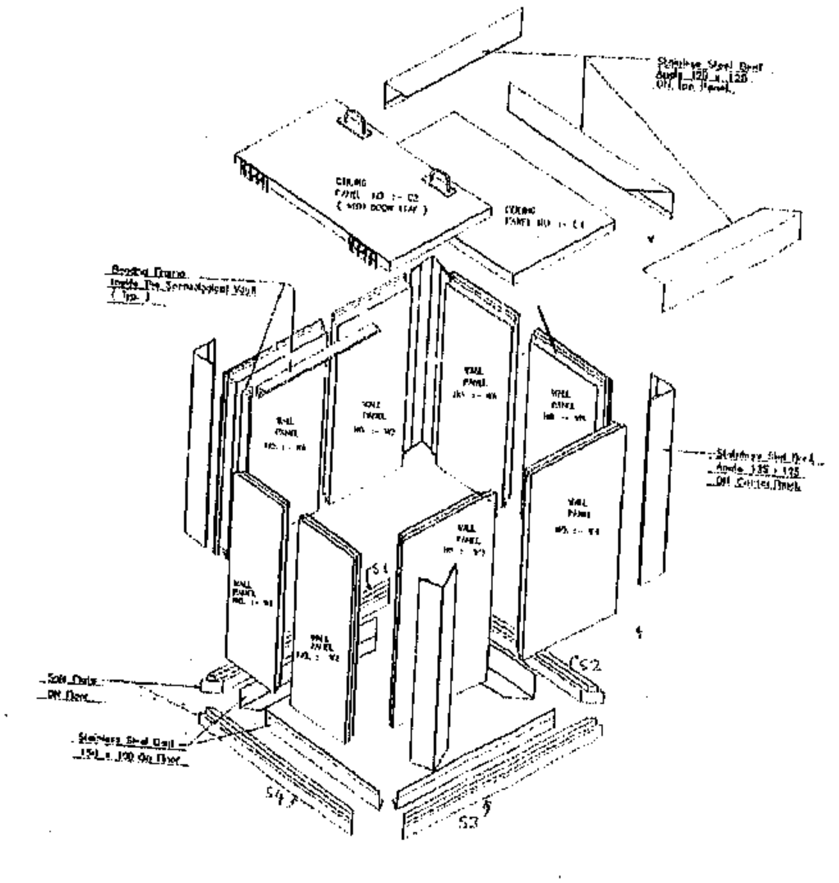


Fig. 6
A schematic of the seismometer vault structure which was burried underground

Fig.7
Digging operation of the seismometer vault pit using bull dozer.

Fig.8
The vault erected on a cement-concrete platform anchored to the bedrock.

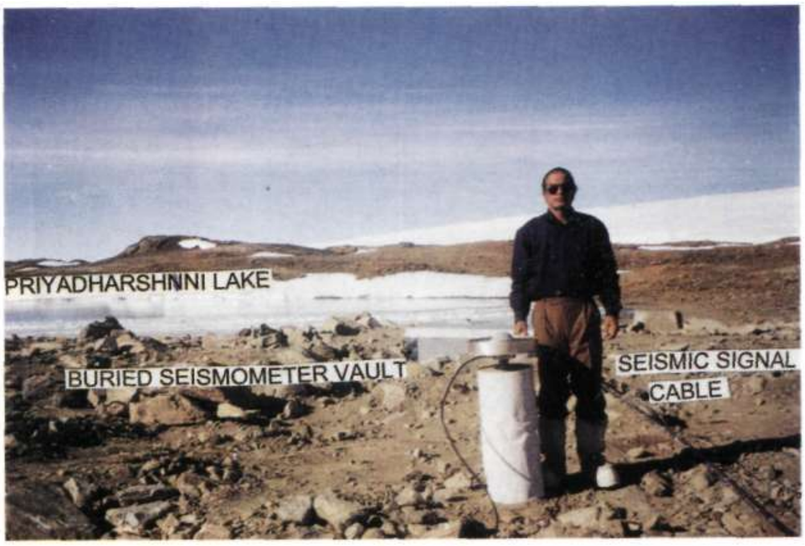


**Fig.9**
**A view of the buried seismometer vault after filling of the surrounding space**


**Fig. 10**
**Inside view of the seismometer vault. Four short period seismometers are use in their respective orientations.**

Fig. 11
A view of the recording system in operation in the Tirumala hut

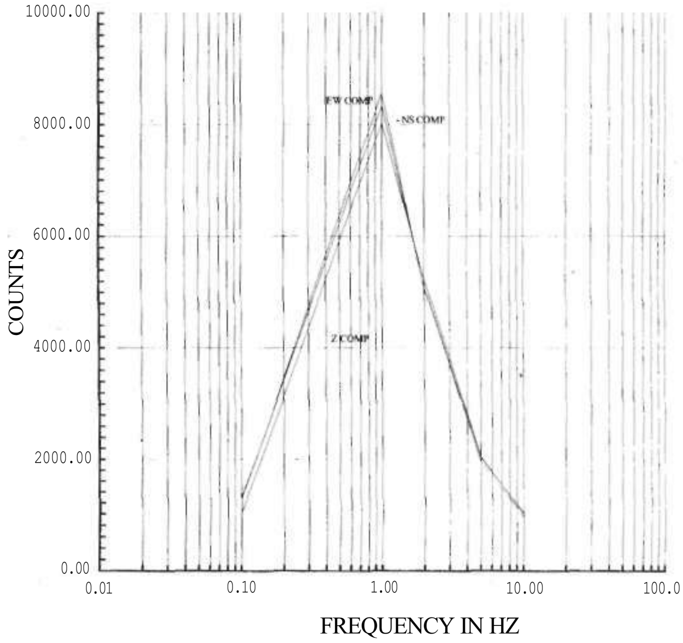


Fig. 12
Systems response for the matched three component short period seismometer (S-13) for a constant current of 7 ma to the calibration coil for various frequencies.

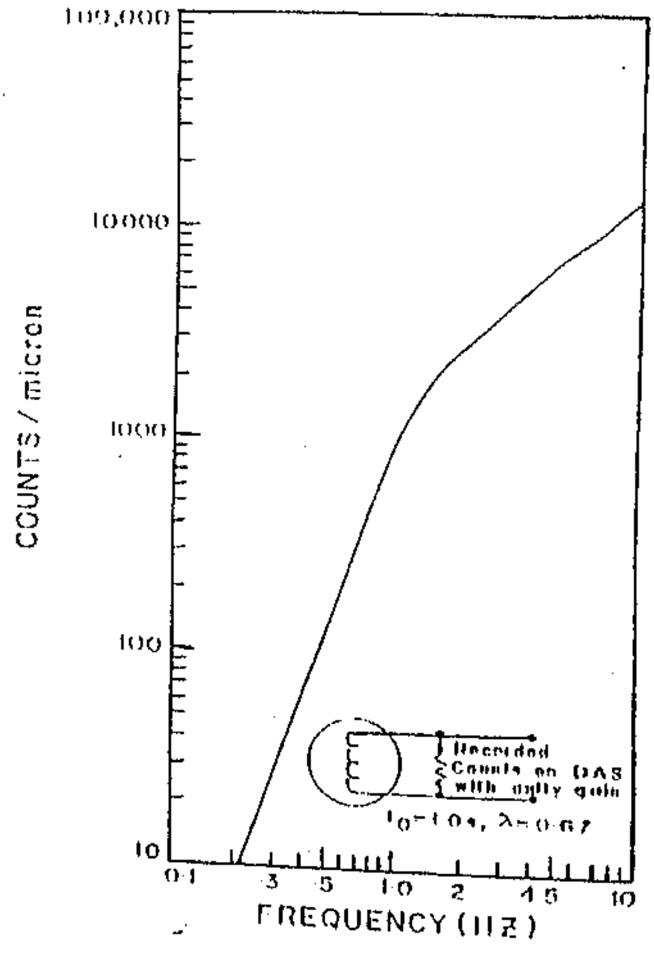


Fig. 13
Displacement response curve for the verticle component digital scsmome.er for a damping constant of 0.67