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DATA COLLECTION SYSTEMS USING SATELLITES FROM THE WORLD WEATHER WATCH PROGRAMME FIRST OPERATIONAL EXPERIENCES AND A SUPPLIER'S POINT OF VIEW

AUTHOR ...... : M.E. CLEVERLEY, *Advanced Projects Manager*
PRESENTERS : A. FRYETT and T. DUFFY
SUPPORTER : R.S.H. ASHWORTH, *Marketing Manager*
McMICHAEL LIMITED
Slough, ENGLAND

SUMMARY

The paper has described the Data Collection Platform (DCP) system in use with the World Weather Watch series of geostationary satellites, the requirements for a family of DCPs operational, the application of DCPs to a network of measuring stations, and the application of DCPs to shipborne data collection.
All the hardware described in the paper is available as a standard product range from McMichael. It is the most extensive and versatile that is available. The various possible configurations ensure that all user needs can be met, provided they conform to the guidelines for data collection in the World Weather Watch Satellite programme.

RÉSUMÉ

La communication décrit le système de plateforme de collecte des données utilisé avec les satellites géostationnaires de la Veille Météorologique Mondiale, les spécifications requises pour la famille de plateformes, la mise en œuvre des plateformes dans le cadre d'un réseau de stations de mesure, et leur mise en œuvre pour la collecte de données par des navires.
Tout le matériel décrit dans la communication fait partie de la gamme des productions de Mc Michael. Il est conçu pour être le plus polyvalent et le plus convertible possible. Les différentes configurations envisagées satisfont à tous les besoins des utilisateurs potentiels tout en étant conformes aux spécifications exigées par le programme de collecte des données par satellite de la Veille Météorologique Mondiale.

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1. INTRODUCTION

This paper is concerned with Data Collection Platforms (DCPs) and their use with the World Weather Watch series of geostationary satellites. Five topics are covered :

- The first topic is a brief general discussion of DCP system concepts using geostationary satellites.
- The second topic is a brief description of the concept of a family of DCPs based on a analysis of likely operational needs which lead to a basic form of DCP around which may variants can be manufactured.
- The third topic is a description of the various types of DCP within the family which are in service in meteorological and hydrological applications.
- The fourth topic is the description of a network of landbased DCPs for a hydrological survey. These DCPs interface with several sensors, include data stores and have data alert facilities.
- The fifth topic deals with operational experience of a DCP used to relay meteorological data from a ship travelling from England to Peru and back.

2. THE DCP SATELLITE SYSTEM CONCEPT

2.1. General

The system consists of a satellite or satellites within whose coverage area on the earth data collection platforms (DCPs) and user receiving stations are located. The DCPs collect data from sensors and send it by a radio telemetry link to the user receiving station via a from sensors and send it by a radio telemetry link to the user receiving station via a satellite.

2.2. Satellites

The paper is concerned with data collection systems using satellites in geostationary orbits, that is, satellites which remain stationary with respect to any point on the earth's surface. In fact, such satellites drift but nowadays the drift is sufficiently small to be irrelevant.

Such satellites contain a great deal of electronics among which is data collection transponder. In principle, the transponder receives radio frequency signals from transmitters on the earth (uplink), extracts the information signal and relays it back to the earth (downlink) at a different radio carrier frequency.

Simple geostationary satellites have broad beam aerials which receive from or transmit to a large fixed area of the earth's surface, the coverage zone. The area covered is typically one-third of the earth's surface area but never includes the extreme polar regions. Thus three such satellites can just cover the earth's surface, while four, five, or even six satellites, properly located, provide increasing degrees of overlap between individual satellite's coverage zones.

One such network of satellites is the series of five satellites in the World Meteorological Organisation's World Weather Watch programme. The coverage provided by this series of satellites is shown in Fig. 1. The names of the satellites are as follows :

METEOSAT
EAST GOES
WEST GOES
GMS
GOMS

The operational schemes described in later sections of this paper use both METEOSAT and EAST GOES.
and

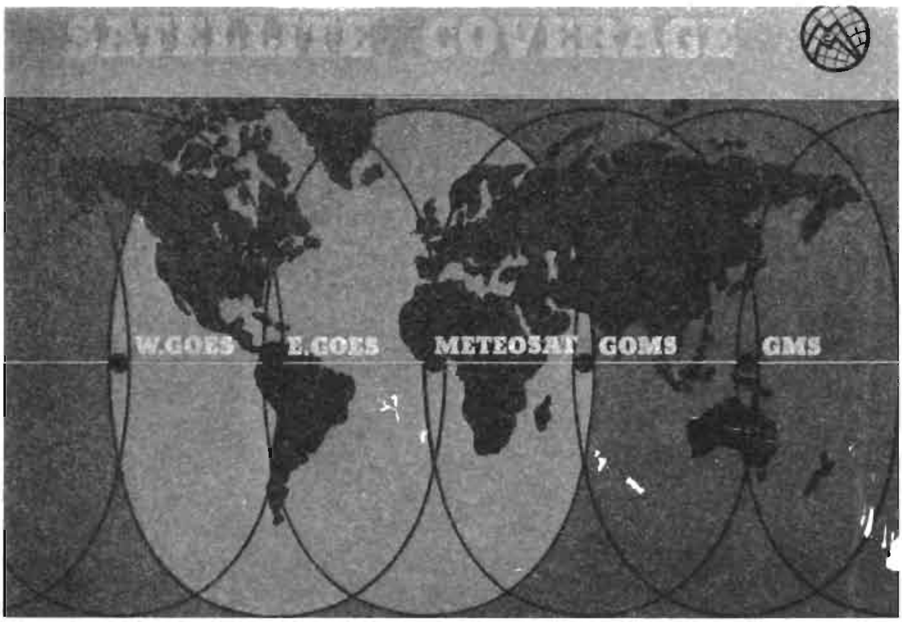

Fig. 1 – WWW coverage ; five satellites

Although the main function of all these satellites is weather imaging using visible light and infra red techniques, each has on board a DCP transponder for the collection of environmental data.
The concept of a system using one such satellite is illustrated in Fig. 2, in which the satellite, DCPs and user ground receiving stations are shown.

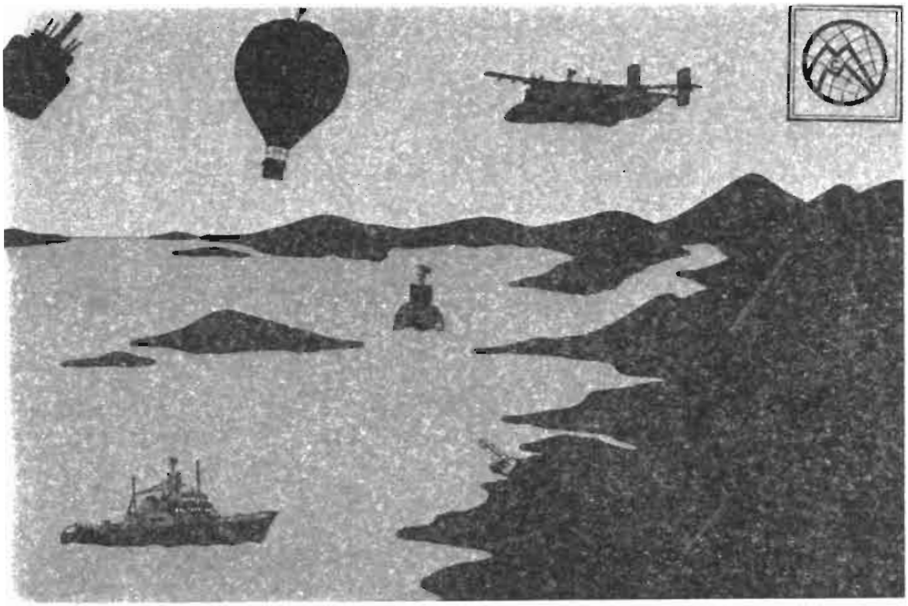

Fig. 2 - System illustration

2.3. Data Collection Platforms (DCPs)

With the coverage zone of the satellite shown in Fig. 2, various types of DCP can be located. DCPs located on land, ships, buoys, aircraft and balloons are indicated in this figure.
DCPs which confine their operations to the area covered by a single satellite are called regional DCPs, while those which may operate through several satellites, for example those on ships or aircraft, are called international DCPs. Different radio channels are used for transmissions from regional and international DCPs.
The DCPs are deployed with and electrically connected to sensors which monitor parameters to do with any of the environmental sciences such as meteorology, hydrology, geophysics and ecology.

To embrace all the possible uses, for the DCPs can operate in several different ways.
The most usual are self-timed DCPs which operate according to an internal clock. At the preset time of transmission, sensor data is passed to the DCP where it is modulated onto a radio carrier and transmitted.
To prevent interference between transmissions from different DCPs, each DCP in the network is arranged to transmit in a particular radio channel at a particular time. Typically, one satellite DCP transponder provides about 48000 time slots of about out-minute duration within a total of some 30 discrete radio channels during the course of one day. Each DCP transmits a preamble code to identify itself, the data and an end of transmission code to complete the message.
An alternative form of DCP includes a receiver which allows it to respond to a user command to transmit sensor data. This is called an interrogated DCP, but, due

to various system constraints, more than very occasional use of such DCPs is discouraged. Interrogated transmissions are arranged only in specially reserved radio channels.
An alert DCP is used where a hazardous situation arises if a particular measured environmental quantity falls outside a limit. Such an event is detected by an alert DCP which then automatically transmits the data to the user using specially designated alert radio channels. It would be unusual for a DCP to be exclusively alert, so an alert DCP is arranged to operate normally as a self-timed or interrogated DCP, the alert procedure coming into action only when an out of limit measurement occurs.

The DCPs may be fixed or mobile. A fixed DCP usually has a reasonably directional aerial which points towards the satellite and a low power transmitter (typically 6 W). A mobile DCP can use the same configuration, provided the aerial is located on a stabilised structure to ensure it points towards the satellite at all times or, and more cost effectively, use a very broad beam aerial to eliminate the need for stabilisation together with a higher power transmitter (typically 60 W).

Other aspects of DCP arrangements are dictated by the way in which data is collected. A number of configurations are possible, for example : single sensors, multiple sensors, analogue or digital interfaces, serial or parallel digital interfaces, external or internal data store/processor/formatter, and so on. All of which demand variations on a basic theme.
Whatever the form of DCP, it has to be approved by the satellite owner before it is used. This is arranged by the manufacturer, who would normally ensure that his whole range of DCPs are acceptable before sale. The operational DCP itself has to be assigned a call code, radio channel number and precise time slots by one of the satellite operating authorities.

2.4. Satellite Receiving Ground Stations

For the user to receive the information from his DCPs via the satellite, a receiving ground station is necessary.
In the DCP arrangements in METEOSAT it is expected that the user will use the Meteosat Control Station (DATTS) located in the Odenwald in West Germany, from which station the data is disseminated to the user using the World Meteorological Organisation's Global Telegraph System (GTS).
The European Space Agency who operate DATTS, guarantee to send the data to the user within two hours of its transmission from the DCP.

Some likely large users are understandably unhappy about this arrangement. The alternative technical solution is simple, the political one may not be. Such a user could equip himself with a Primary Data User Station, PDUS, fitted with a suitable receiver, decoder and data processor and receive his data directly from the satellite. In this way he receives his data within about 1/4 second of its transmission from the DCP, without the delay in dissemination of DATTS and without the risk of loss of data due to a brekdown in the GTS. (A PDUS is usually used to receive weather pictures rather than DCP data transmissions).

The control station accesses only the satellite it controls, and a PDUS would also usually, but not absolutely always, access only one satellite. So a user of international DCPs which may pass through many coverage zones has to rely on data being disseminated to him from the individual satellite control stations over GTS.

2.5. Data Formats

The satellite operators prefer the DCP user to opt for one of the 19 WMO codes which have been approved for use in the system, but almost any data format could be used.
If approved data formats are used, it is usual for the DCP operator not to be charged for the use of the satellite, the satellite control station or GTS. If non-standard formats are used, or data processing at the Control Station is required, charges are levied.

3. CONCEPTUAL REQUIREMENTS FOR A FAMILY OF DCPs

3.1. General

It is clear from the comments in section 2.3 that although the DCP principle is quite simple, there are many different ways in which they may need to be used. These differences lead to the conclusion that a single type of DCP will either be too simple to be of interest to all possible users, since it will operate in only one manner, or too complicated and costly if it is designed to operate in any likely manner. The best approach to the problem is to develop a family of DCPs around a basic unit with any additional facilities provided by extra modules fitted within the DCP box. The DCP needs to be simple to set up and use, and have a minimum of controls.

The solution adopted by McMichael Limited is to employ a basic DCP comprising a number of electronic printed circuit boards (PCBs) mounted in an open PCB frame which provides ready access for setting up and repair, and mounting the whole frame in a metal box with only a few controls and sockets on its front panel.

The DCP is based around a microprocessor controller, and the operation of the DCP is arranged by the use of pre-programmed software. Thus the only external controls are an ON/OFF switch and a timing synchroniser switch to set the actual time on deployment and to initiate the software control programme.

3.2. Basic self timed DCP

A block diagram of a basic self timed DCP is shown in Fig. 3. The basic DCP includes :

(a) a microprocessor based transmitter controller which turns the transmitter on, triggers the presentation of data at the DCP imput at the transmission time and adds the preamble and end of transmission codes around the data.
It also includes a transmitter shutdown timer to turn the transmitter off in the event of controller failure.

(b) a single imput interface which accepts serial data at the rate of 100 bits per second at the time of transmission.

(c) a highly stable crystal controlled clock and oscillator which provides the timing signals to initiate transmission and a stable signal defining the transmission radio frequency.

(d) a radio frequency modulator (phase modulator) and low power transmitter (6 W).

(e) a narrow beam aerial directed to the satellite.

That, together with a source of power (mains or battery) constitutes a basic self-timed land-based DCP, the parts of which, with the exception of the aerial, are housed within a single compact box which may be free standing or rack mounted.

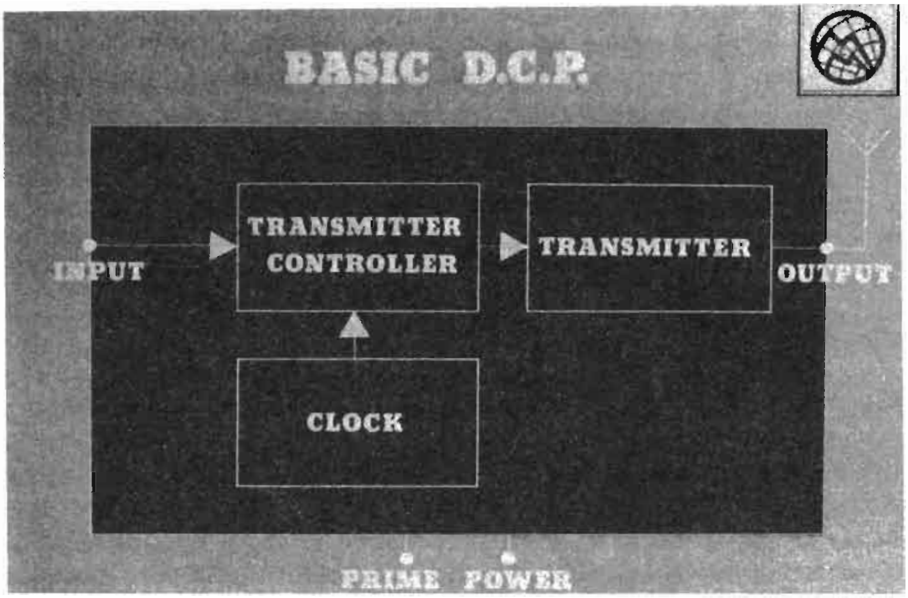

Fig. 3 – Basic block diagram

3.3. Alternative DCP options

The PCB card frame used in the basic DCP has sufficient pre-wired spare capacity to permit all likely options to be incorporated within the DCP box. A vari‿ty of these optional additional facilities are indicated schematically in Fig. 4.a and b.

(a) Interrogated DCP

An interrogated DCP uses the transmit aerial. A special diplexing filter is provided in the aerial lead within the box to direct the received interrogation signal to the special receiver module which extracts the interrogation command. This signal is applied to the transmitter controller to activate the DCP, for which procedure special pre-programmed software is incorporated.(fig. 4a).

(b) Alert DCP

All the DCPs in the McMichael range include in the transmitter controller and its software the means to provide alert facilities. If it is required, the alert connection made to the sensor imput scoket and the special alert channel radio frequency generator is made operative by including a suitable plug-in crystal in an otherwise vacant socket (fig. 4b).

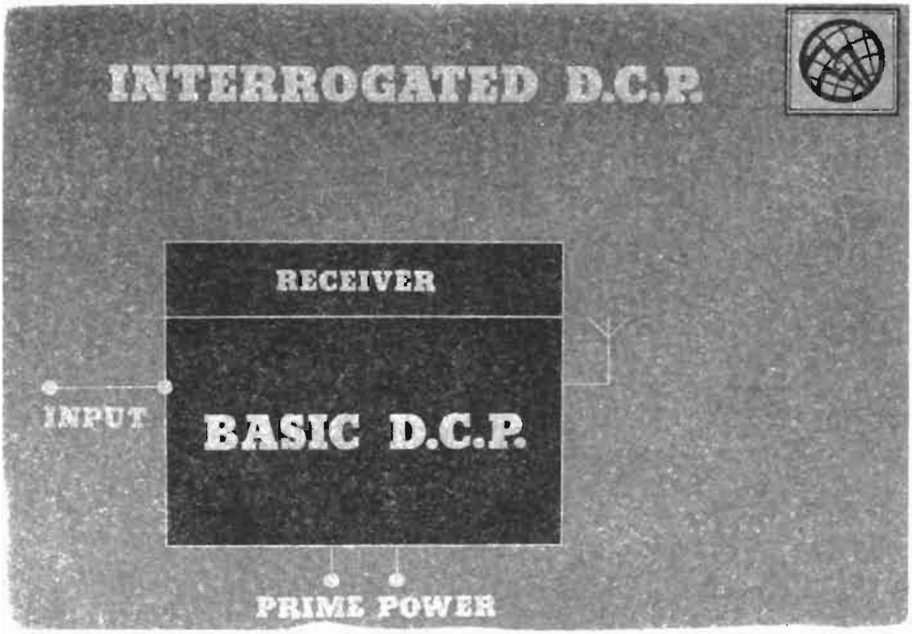

Fig. 4a – Option block diagrams

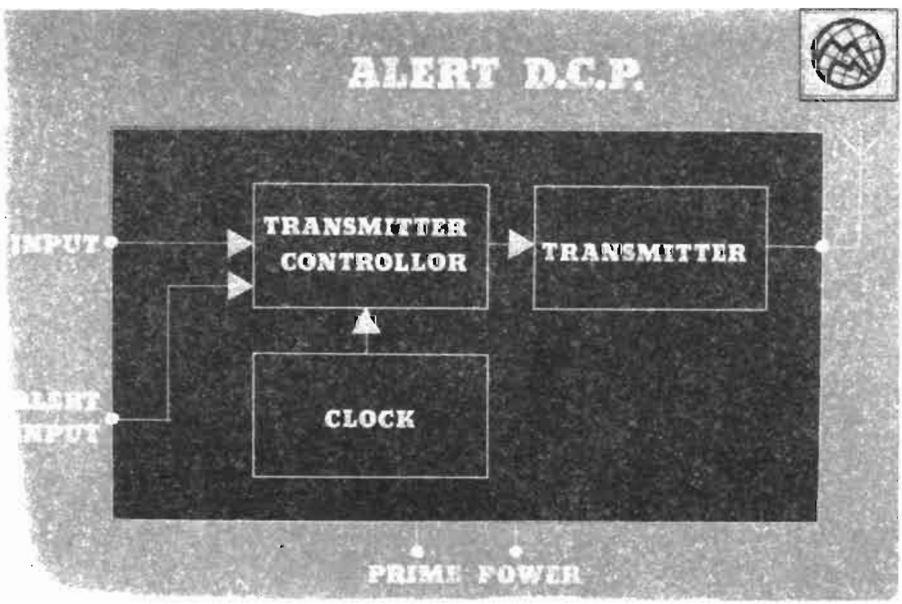

Fig. 4b – Option block diagrams

(c) Mobile DCP

The narrow beam aerial is replaced by a broad beam aerial and within the DCP box a high power (60 W) transmitter is included. This fits into a special compartment beneath the card frame. The low power transmitter is retained as the drive amplifier to the high power unit. To conserve prime power and to reduce heat dissipation within the box, a special highly efficient power amplifier is used.

(d) DCP with processor controlled data store and special input interfaces

There is sufficient space available within the DCP to fit a set of PCBs for a microprocessor controlled data store. The PCBs are identical to those used for the transmitter processor and its program store. Space is also available for a variety of input interfaces to be incorporated.
The software for the processor controller can be varied at will during manufacture by the inclusion of specially selected solid state memory chips, so such a DCP is extremely adaptable. Just a few examples of the use of such a facility are :

- interfacing directly with sensors (up to six sensors can be handled simultaneously)
- independant sampling of each sensor
- 8 bit or 16 bit parallel data inputs
- analogue data inputs
- a synchronous data inputs (teletype compatible)
- data formatting
- storage of data to the capacity on one time slot (5Kbits) or two time slots (10Kbits) in some configurations.
- alert facilities for none, some or all of the imputs.

3.4. Comments

The use of a basic DCP together with a range of built-in options allows McMichael Limited to offer an extensive but standard product range of DCPs.
The flexibility provided by the use of a microprocessor based scheme with software control ensures that this range of DCPs can be used in any data collection system.

4. OPERATIONAL DCP EQUIPMENT

Various DCPs and periphals are shown in Figures 5-10.

- Figure 5 shows the outside and inside of a basic self timed DCP. It is the actual DCP approved by ESA.
- Figure 6 shows the narrow beam aerial.
- Figure 7 shows a basic DCP with high power transmitter located under the card frame.
- Figure 8 shows the broadbeam aerial.
- Figure 9 shows the outside of a 6 input DCP with data store.
- Figure 10 shows a DCP Synchroniser. This unit is contained within a small box and has a flying lead to connect it to a synchroniser socket on the DCP. It is attached to the DCP to set the internal clock to GMT when the DCP is first set up. It can also be used to check that the DCP is functioning. Only one synchroniser is ncessary for a network of DCPs.

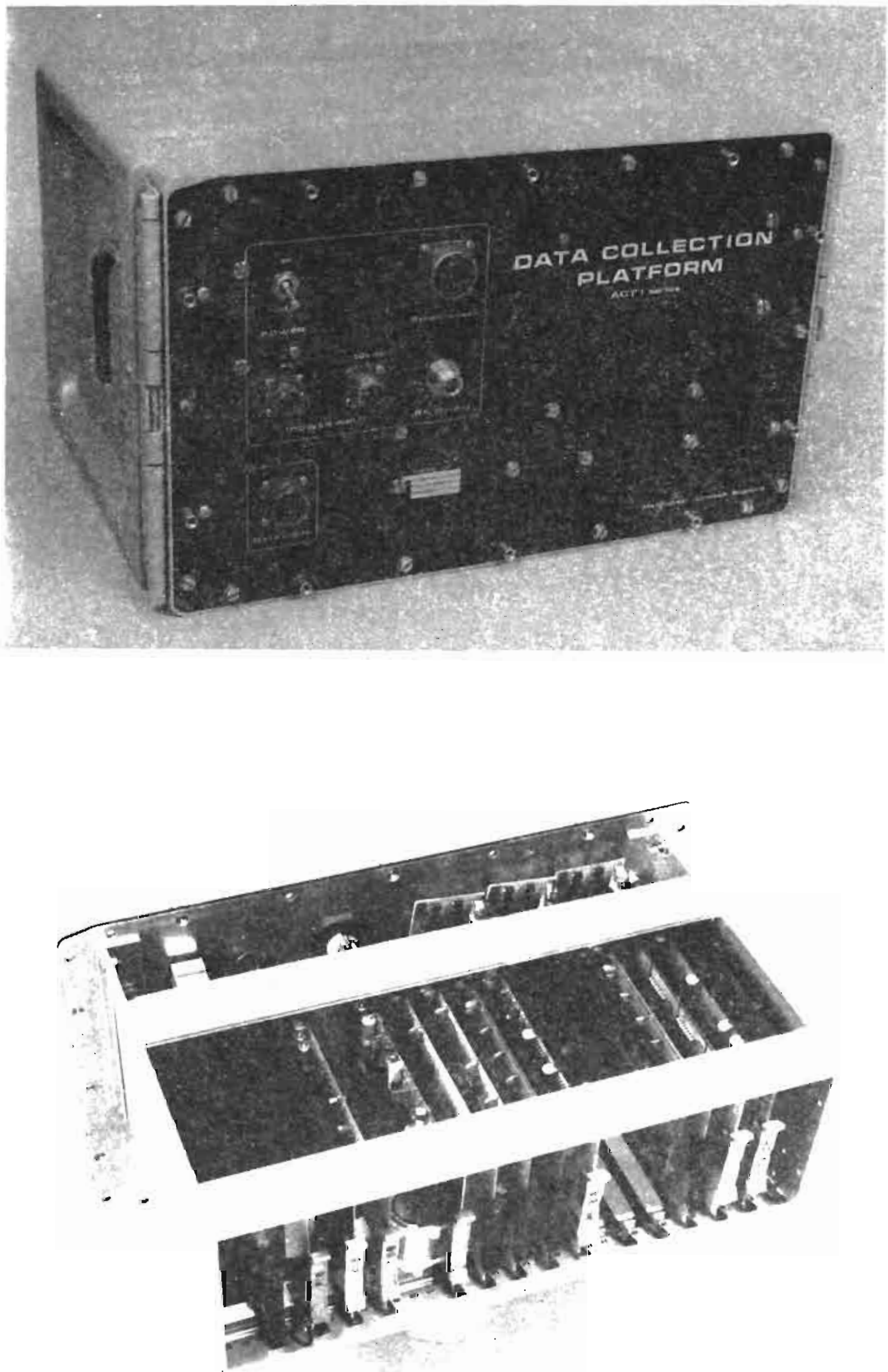

Fig. 5 – Outside and inside of basic DCP

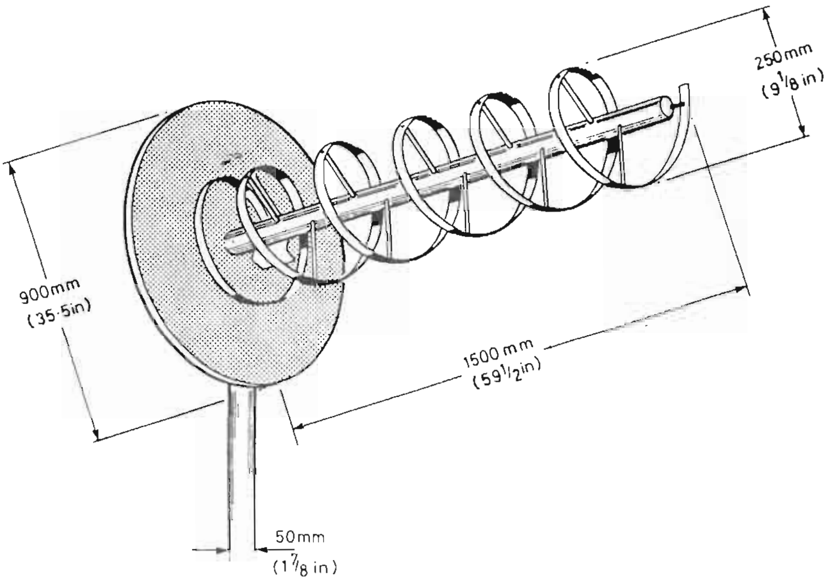

Fig. 6 – Narrow beam aerial

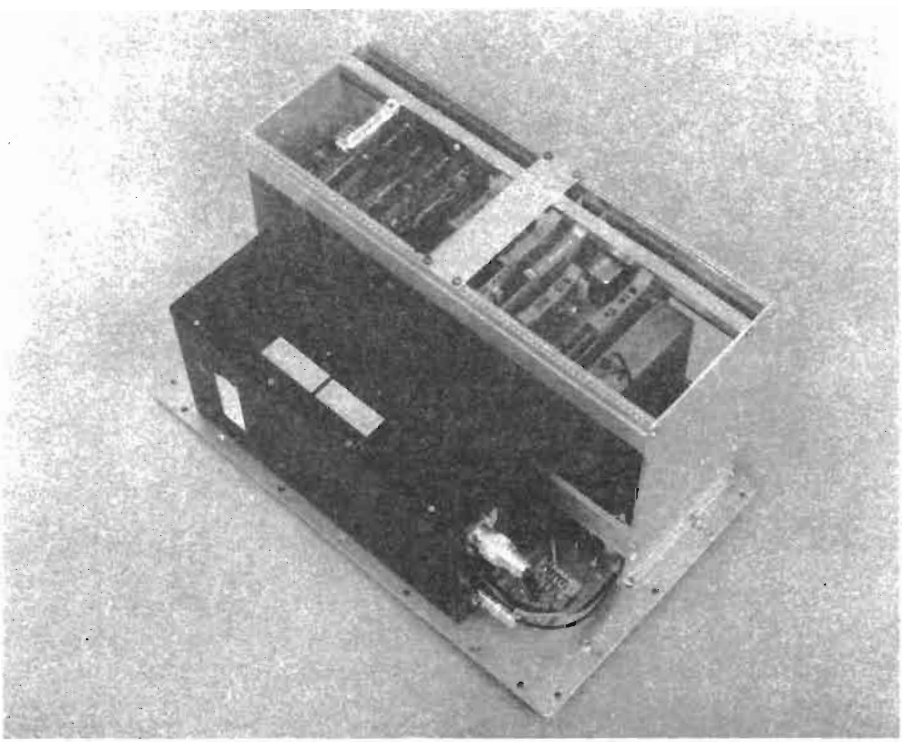

Fig. 7 – Ship DCP - Inside

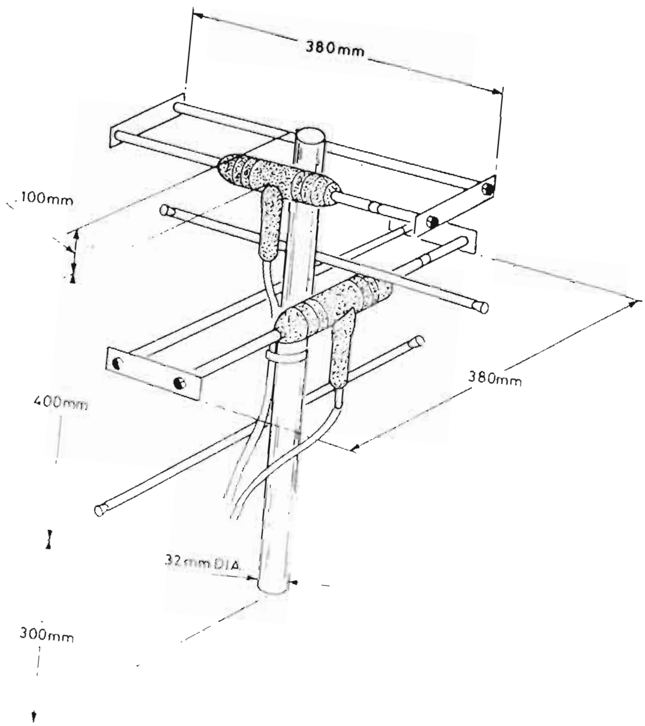

Fig. 8 – Broadbeam aerial

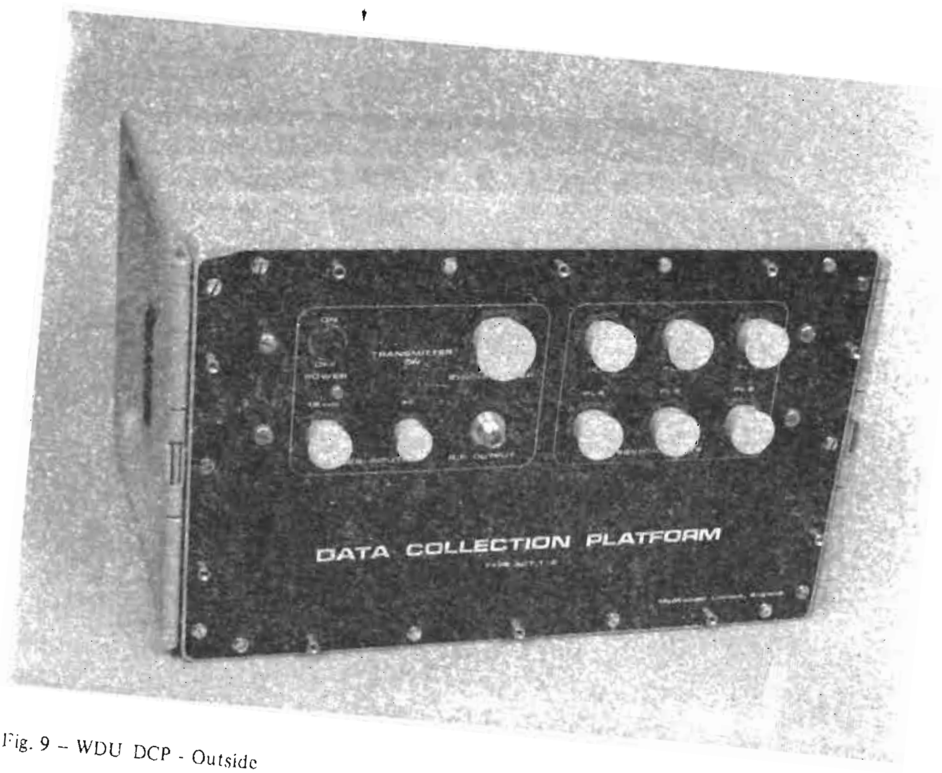

Fig. 9 – WDU DCP - Outside

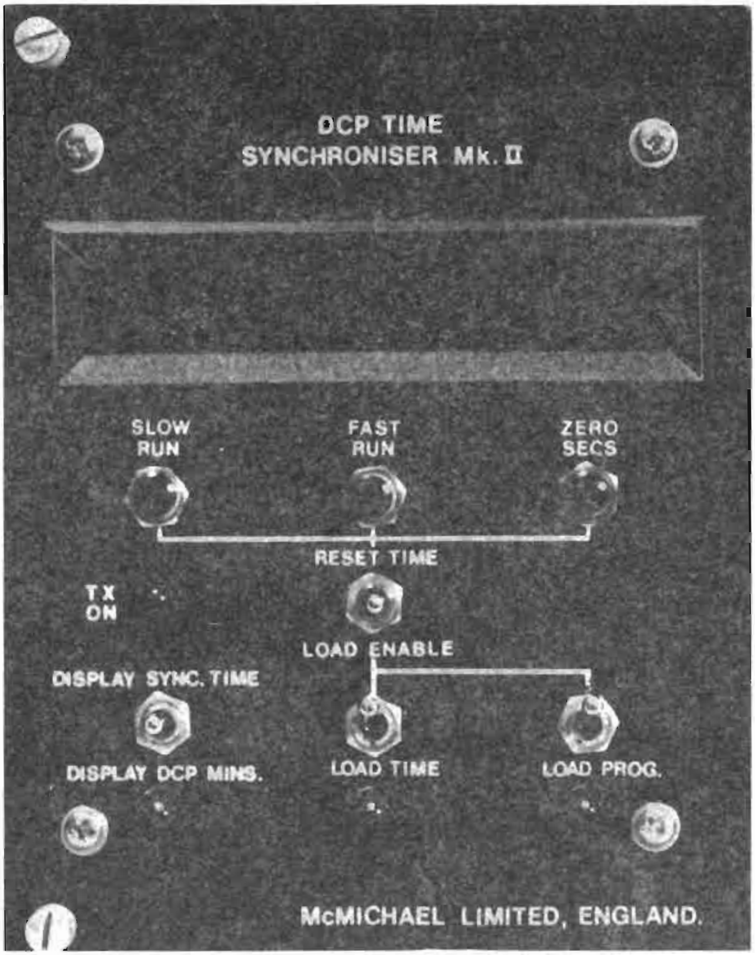

Fig. 10 – Synchroniser

5. NETWORK OF LANDBASED DCPs

The first application of DCPs is a hydrological system in which an area is covered using a co-ordinated set of sensors and DCPs.
This project, which will be fully operational in a few weeks time, is being organised by the Water Data Unit of the United Kingdom Department of the Environment, in collaboration with several regional Water Authorities.
The operational network consists of four DCPs deployed in England, a fifth DCP is also available but is normally retained by the Water Data Unit at Reading, See Fig. 11.

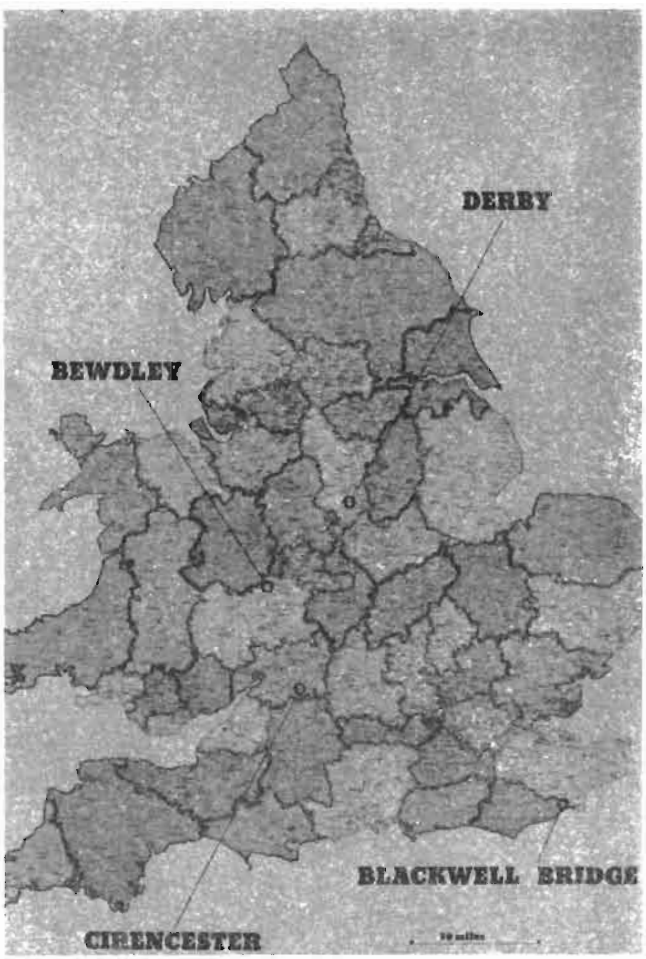

Fig. 11 Deployment of DCPs in UK

Only two locations use the same hydrological equipment so there are three different versions of the McMichael DCP in use in the project.
The two identical units are at Bewdley, which is rural, and Derby, which is urban. At these two stations, the DCPs are connected to Leupold and Stevens river level recorders.

The other two are at Blackwell Bridge, mear the South-east coast, where a Harwell ultrasonic gauging equipment is located, and Cirencester, towards the west of England, where a rain gauge is being used.

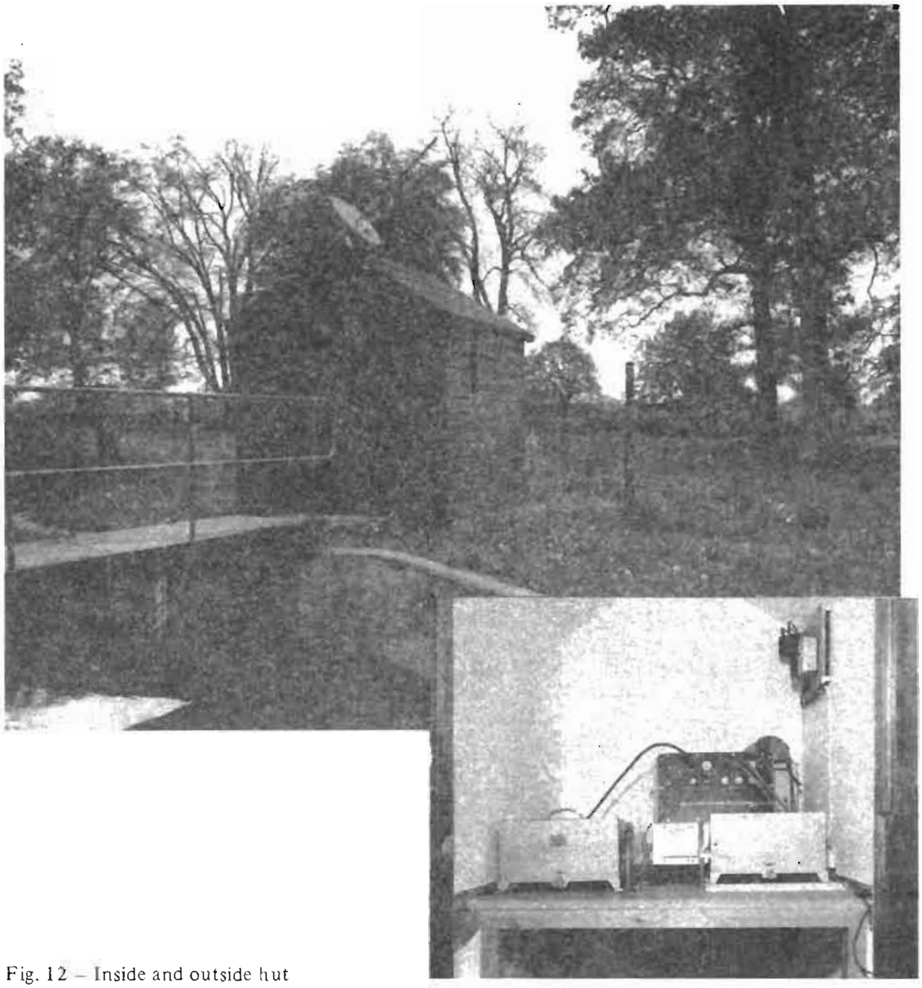

Fig. 12 – Inside and outside hut

A typical installation is shown in Fig. 12. The narrow beam spiral aerial is mounted on the roof of the hut, pointing towards the satellite. Inside the hut the DCP stands on a bench connected to the hydrological instrument.

The general configuration of these DCPs is as follows :

- Code Names : GB/Water 1, 2, 3 and 4.
- Type : Regional DCP.
- Configuration : Basic self timed DCP with data store and alert.
- Inputs : 8-bit or 16-bit parallel data interfaces, 2 or 4 inputs used.
- Data collection intervals : 15 or 30 minutes.
- Data transmission interval : 24 hours.
- Data Format : WMO Miscellaneous (SX) Code, GTS compatible.

As the network is not yet fully operational, it is not yet possible to comment on its effectiveness.
This project is the first operational application of DCPs using Meteosat in a network covering a reasonable area.
The four DCPs are also the first ones with alert facilities to be allocated code names, channels and time slots by the ESA.

6. DCPs AT SEA

McMichael participated with the United Kingdom Meterological Office in an evaluation of the use of the DCP system for the relay of meteorological data from ships at sea.
A small meteorological station is often fitted to ships crossing the Atlantic Ocean and it is usual for the ship's crew to be involved in data collection. With a DCP system the whole arrangement would be automatic.
The DCP together with the meteorological equipment was fitted to the OROPESA, which is shown in Fig. 13.

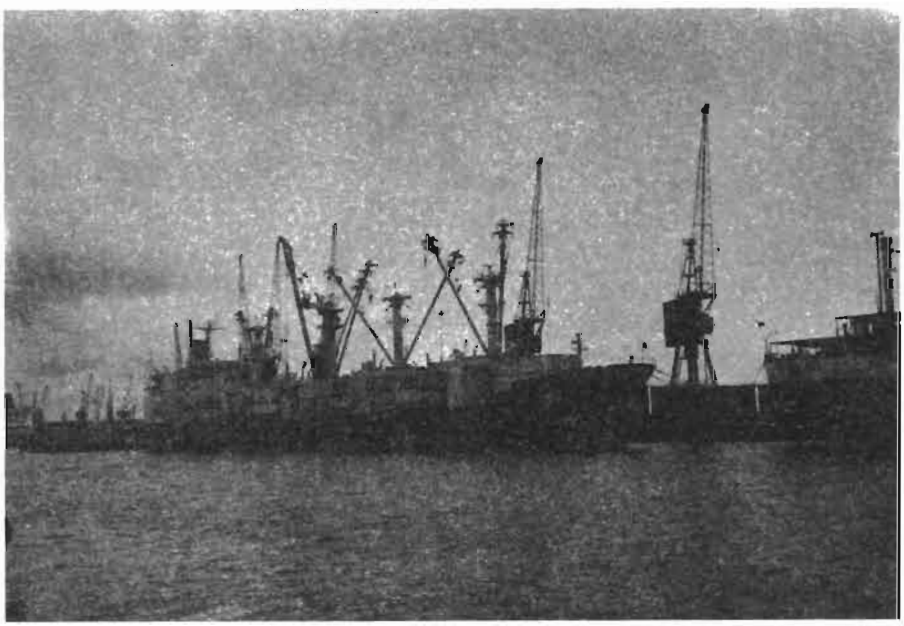

Fig. 13 – Ship

The DCP aerial installation is shown in Fig. 14a. It stands only 1.2 metres away from the ship's main radar aerial which radiates 20 kW. The arrangement in the equipment cabin is also shown in Fig. 14b. The equipment includes : windspeed and direction recorders, air pressure and temperature recorders, humidity recorder, an Automet Automatic Data Recorder and the DCP itself.
It had been intended to include a ship's position recorder but this could not be fitted before the ship sailed.

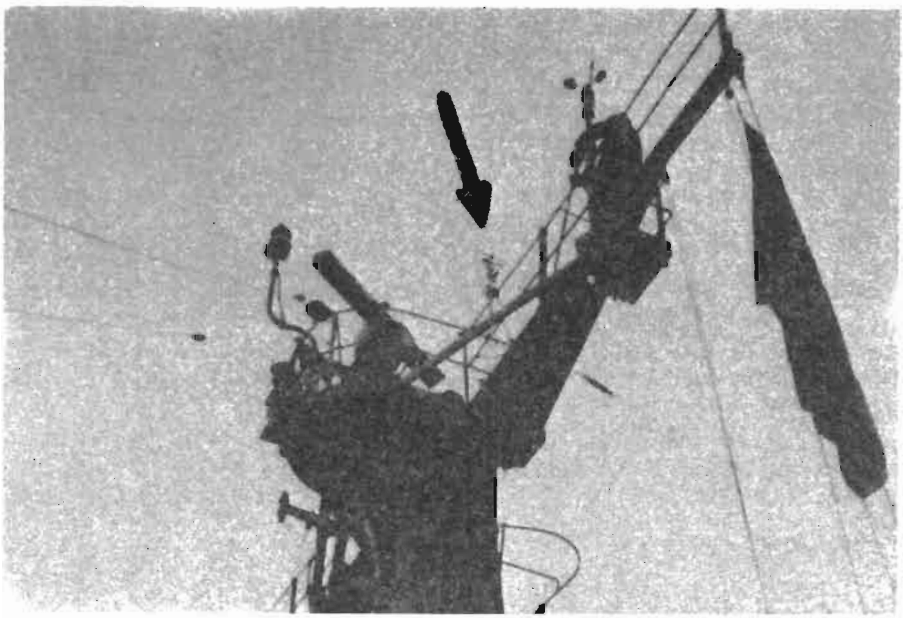

Fig. 14a – Ship aerial installation

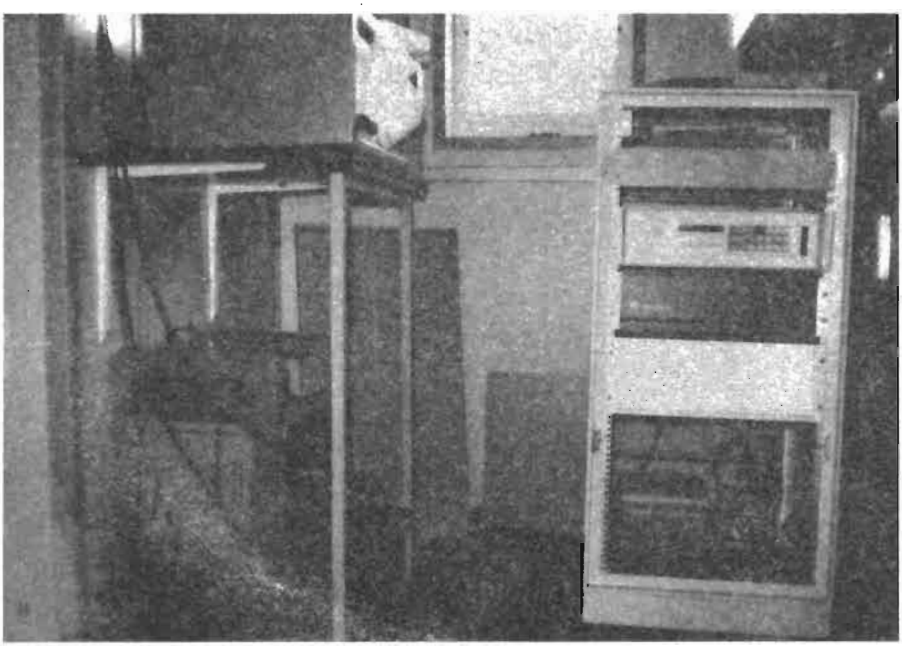

Fig. 14b – View inside cabin

The configuration of the DCP was as follows :

- Code Name : GB/MARITIME
- Type : International DCP
- Configuration : Basic self timed DCP, high power transmitter, broad beam aerial
- Input : Single input serial data
- Data Collection Intervals : not applicable (data collected and stored externally, 60 minute intervals)
- Data Transmission Interval : 6 hours
- Data Format : WMO SHIP Code, GTS compatible

It crossed the Atlantic Ocean to Bermuda, then through the Panama Canal and on to Peru, from which location it retraced its route back to England, arriving on 24th May. The route is shown in Fig. 15.

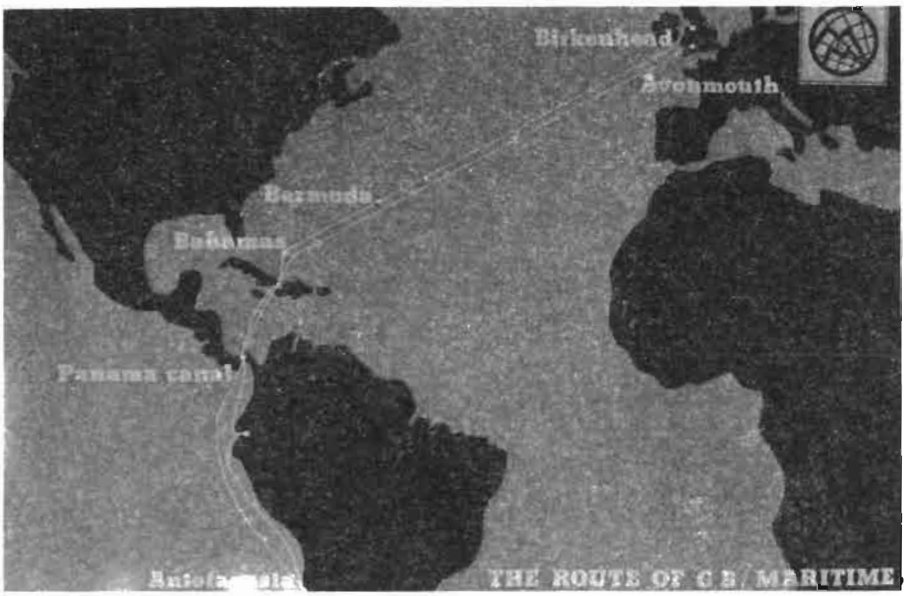

Fig. 15 Ship's route

For most of the journey the ship was in view of Meteosat and data was returned to the Met. Office from the ESA receiving station in West Germany. For the remainder of the journey the ship was in the view of only East GOES, and data was returned from its control receiving station to the Met. Office over GTS.

The Met. Office and ourselves are evaluating system performance while the ship was in view of Meteosat. At present we are trying to estimate the location of the ship at the DCP transmission times by manual analysis of the ship's log. Our first rough estimates are that we achieved 100 % data capture inside the recommended Meteosat operating area, that we achieved 50 % data capture in the fringe area where operation is not recommended, and that intermittent data capture was achieved even further out, the furthest transmission being $1^1/_2$° S, 80° W, which is very surprising since the satellite could hardly view the ship at that location.

A typical format of data received by the Met. Office is shown in Figure 16.

```
 DCP:GE/MARITIME        (ECH-ADDR.=11802772)

DATA RECEIVED SINCE LAST PRINT REQUEST AT:
                                                  YEAR:79 DAY:116 TIME:06.05.43

   1. MESSAGE OF DCP:GE/MARITIME       (ECH-ADDR.=11802772)
                                                  RECEIVED ON CHANNEL: 15 A1
                                                  YEAR:79 DAY:116 TIME:06.17.01

DCP DATA  ([illegible] ADDRESS.HEXADECIMAL, FIRST DATA BIT ON BYTE [illegible].
5163 6368 [illegible] [illegible]13 920F 049D 9DF4 F4F4 04F3 51[illegible] [illegible]F4 044C
[illegible] 8C2C 04F4 CDCD 0D9D 04F4 F4F4 F4F4 048C 3D4C 8C2C 04F4
F4F4 F4F4 040D 0D4C 8C6D 0101 0101 0101 049D CC8C 9D4C 94D6
847F EADE EF76 5701 0511 9278 1A0D 800D 0D04 4913 040D 9D04
.... .... .... ETC. .... .... .... .... .... .... .... ....
.... .... .... .... .... .... .... .... ....
.... .... ....ETC. ..........
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Fig. 16 – Data format

7. ACKNOWLEDGEMENTS

I would like to thank the Meteorological Office and the WaterData Unit for their cooperation in preparing this paper.