H.M.S. 'CHALLENGER' SEABED OPERATIONS VESSEL ELECTRICAL SYSTEMS

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PART III—DYNAMIC POSITIONING

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Introduction

The previous articles dealt with the high-voltage propulsion system and control of steering and ship speed. This article deals with the dynamic positioning (DP) system which operates with the other systems to provide:

(*a*) A primary dynamic positioning mode to position the ship in water depths to 300 metres.

(*b*) Auxiliary DP modes which include automatic track following/manoeuvring, manual maneouvring, and general DP.

This article concentrates upon the primary dynamic positioning mode of operation. The overall ship control system is being supplied by Marconi Space and Defence Systems Ltd., Frimley. The dynamic positioning system forms part of this overall system and the work has been sub-contracted to GEC Electrical Projects Ltd., Rugby. FIG. 1 shows the MSDS system and GEC(EP) involvement. The description of the primary DP mode of operation is mainly concerned with the GEC(EP) equipment.

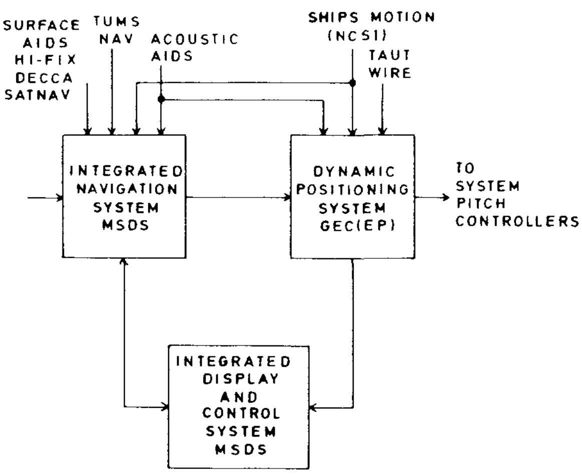

FIG. 1—OVERALL MSDS SYSTEM

An explanation of the basic DP principles is followed by an examination of how these principles are applied in the SOV system with a brief description of the hardware and software involved. For the primary DP mode, it is shown how the vessel is normally taken into automatic position and heading control, with a look at the emergency arrangements. It ends with a short explanation of the auxiliary DP modes.

Basic Principles of Dynamic Positioning

The vessel has six freedoms of motion—heave, pitch, roll, surge, sway, and yaw as shown in FIG. 2. The motions of heave, roll, and pitch do not affect the position or heading of the vessel, and these motions involve forces that are too large to be controlled. The DP system is therefore designed to control the surge, sway, and yaw motions of the ship.

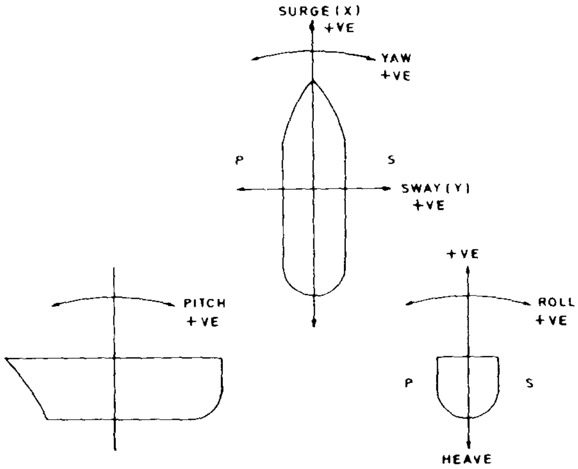

FIG. 2—SIX FREEDOMS OF MOTION

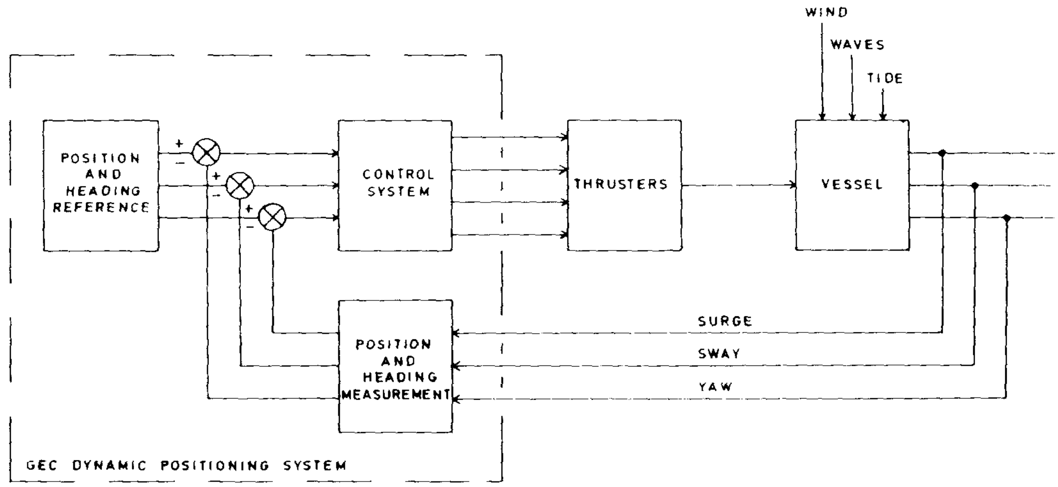

FIG. 3—SIMPLIFIED BLOCK DIAGRAM OF A DP SYSTEM

A simplified block diagram of a DP system is shown in FIG. 3. The control system compares the required position and heading with actual measured values of position and heading. The control system then produces thruster pitch demands to move the vessel to the required (or reference) position and heading.

The SOV Dynamic Positioning Equipment

A block diagram of the SOV system hardware is shown in FIG. 4. Two Type 4070 GEC computers are sited in the Computer Room and maintain the position and heading of the ship by controlling the pitch on the bow thrusters and Voith Schneider propellers. The computers are each capable of performing the control function independently using data from acoustic or taut-wire sensors. In the event of failure in the controlling DP computer, a smooth changeover to the back-up computer system will occur.

There is also a DP control console housed in the operations room for manual control of the vessel when in DP mode and for selection of required position and heading.

An emergency system is provided for use in the event of total failure of the main DP system. The emergency system comprises a microprocessor cubicle with manual controls which are also sited on the main DP console. This system has capabilities limited to automatic control of ship's heading and manual control of fore/aft and lateral ship movements.

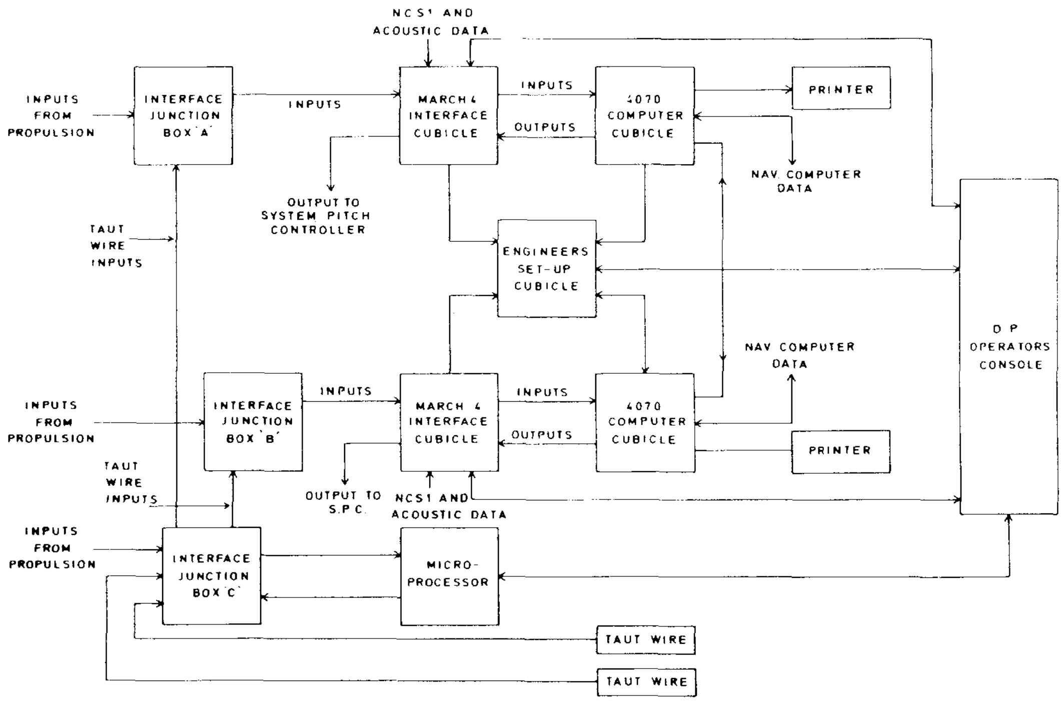

FIG. 4—BLOCK DIAGRAM OF GEC DYNAMIC POSITIONING SYSTEM

FIGS. 5,6, and 7 show views of the console, March 4 Interface Cabinet, 4070 Computer Cabinet and Engineers' Cubicle taken whilst the equipment was under test at Rugby.

Position Sensors

The ship's position is determined from two independent measuring systems of which the acoustic is the primary. This acoustic system operates by

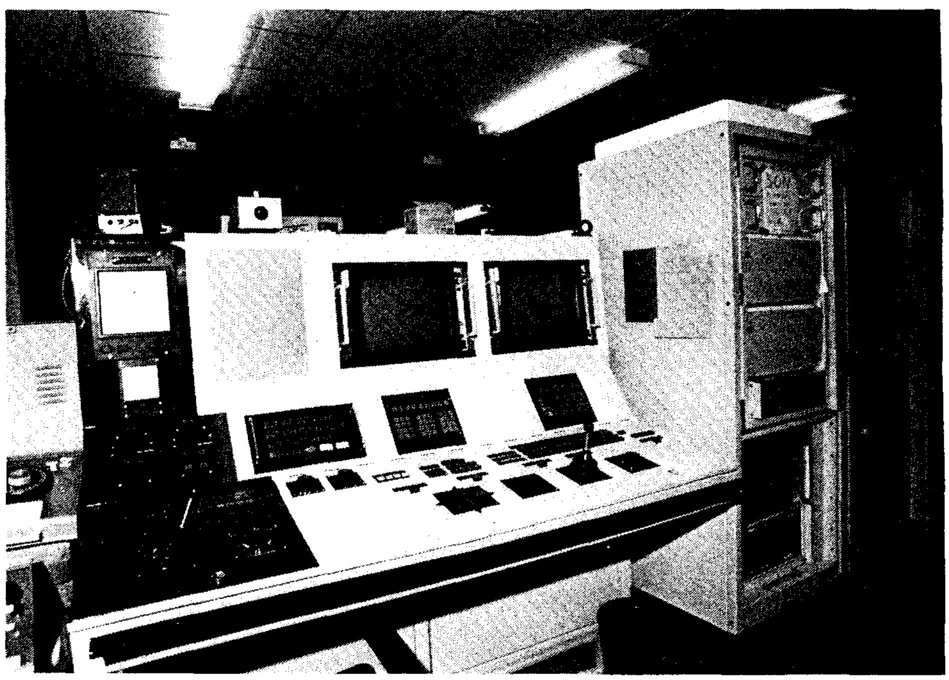

FIG. 5—CONSOLE AND MARCH 4 CABINET

FIG. 6—ONE COMPUTER RACK

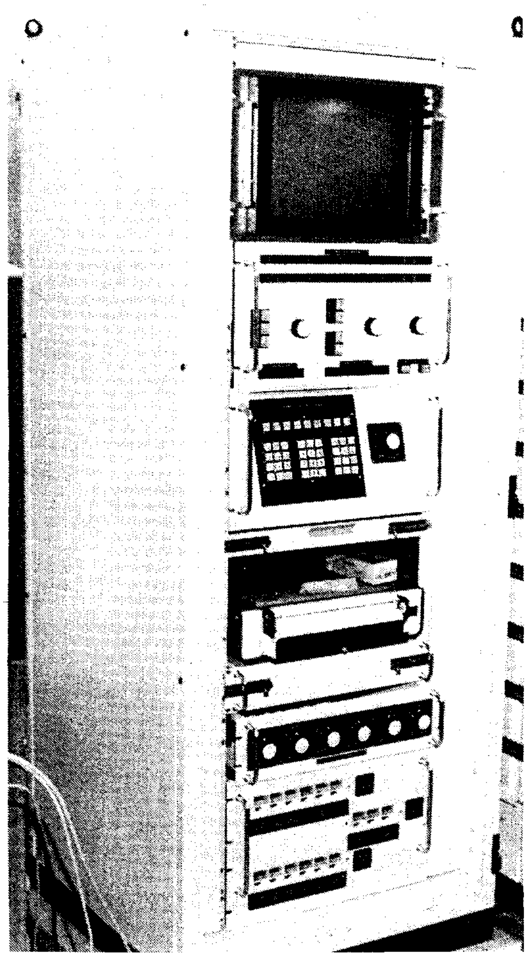

FIG. 7—ENGINEER'S SET-UP CUBICLE

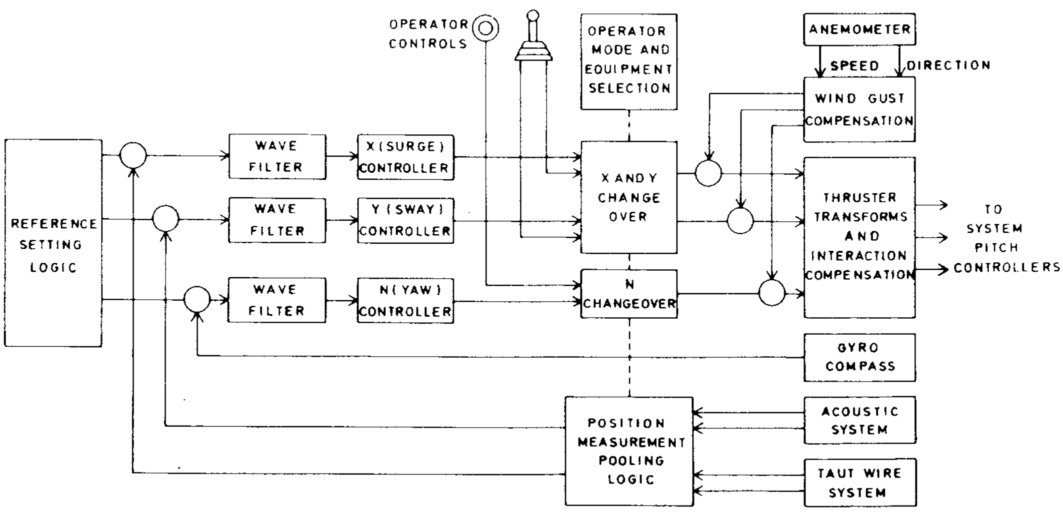

FIG. 8—BLOCK DIAGRAM OF THE GEC SOFTWARE CONTROL SYSTEM

receiving signals from up to three free-running acoustic beacons laid on the seabed; their signals are received on an array of stalk-mounted or hull-mounted hydrophones. Changes in ship position can then be calculated by measuring the difference in time of arrival of the beacon signals at the stalk hydrophones, and compensating for change in heading and attitude. Hull-mounted hydrophone arrays may also be selected (two from four) to provide two additional acoustic fixes from each beacon. In each DP system, acoustic data will be put in via an acoustic interface unit and processed by a software acoustic processing segment to give an optimum choice of hyrophones to obtain ship position.

Secondary position information to supplement the acoustic system is provided by two taut-wire systems. These provide position signals derived from inclinometers which measure the angle of the taut wire to the vertical in two planes. The taut-wire system is simply a sinker weight which is lowered from a davit to the seabed with the wire maintained under constant tension. The ship position can then be measured by a voltage signal derived from the inclinometers.

Control System Software

The GEC software control system block diagram is shown in FIG. 8. The function of the software is to relate thruster pitch setting to position and heading errors and the effect of external disturbances. In general this is performed once a second, but output commands to the thrusters of required pitch settings are made once every four seconds. The DP system software is mainly written in a high-level language called CONRAD. The component parts of the software of the DP control system are described below:

(*a*) *Pooling Logic*—the acoustic system has high accuracy but with short-term drift. A taut-wire system has reasonable accuracy with long-term drift. The pooling logic combines the best characteristics of each system.

(*b*) *Reference Setting Logic*—this sets the position and heading references for the control system. They are set to the vessel's actual position if the beacon is coincident with the target position. If the target is elsewhere, offsets in earth co-ordinates are stored for offsetting subsequent measurements. The reference can be changed by the operator or automatically as in auxiliary modes.

(*c*) *Wave Filters*—the position and heading measurements include high frequency motions in surge (X), sway (Y), and yaw (N). If they reach the heading and position controllers the result will be oscillation in thrust and power demanded from the thrust devices. The DP system therefore needs some form of filter to reduce the thruster activity to an acceptable level.

(*d*) *Loop Controllers*—the three loop controllers determine the longitudinal force, lateral force, and turning moment required to correct the position and heading errors.

(*e*) *Wind Gust Compensation*—this is included to overcome inherent delays in the closed-loop control system when responding to rapid changes of wind. Wind measured by anemometers is filtered to remove high-frequency components of wind gusts to reduce unneccessary thruster modulation. The result is processed to produce longitudinal, lateral, and turning moment forces for adding to the output from the main loop controllers.

(*f*) *Thrust Transforms and Interaction Compensation*—the required X, Y, and N forces from the loop controllers are passed to the transform which also receives status information about the available thrusters. It then determines the most efficient deployment of the available thrusters to counteract the required X, Y, and N forces and sets the required pitch demands.

The foregoing gives some idea of how the software in the computers functions to achieve required thruster pitch settings. Having mentioned virtually all the hardware and software and briefly explained how it all works, the operation of a few of the more important controls is explained to give a 'feel' for the system.

System Control

FIG. 9 shows a drawing of the DP console with important controls labelled. To put the ship into a primary DP mode of operation after completing passage to an area for deployment of the divers and diving bell, ship control is passed to the DP console operator as follows:

Phase 1—Joystick and Manual Heading Control

Each computer accepts demands from the joystick and turning moment controller and translates them into appropriate individual thrust and pitch demands for the selected propulsion/thrust units in operation. The vessel will move in the direction of the joystick. The turning moment controller can be moved either clockwise or counter-clockwise to rotate the vessel about the centre of the ship. By using these controls with the display of position and heading, the ship can be dynamically positioned manually by balancing weather forces acting on the ship with thrust forces from the controls.

Phase 2—Joystick and Automatic Heading Control

When joystick/auto-heading control is selected the joystick controller is used in the same manner as for Phase 1. The vessel's heading, however, is now controlled automatically by the DP system to the heading set by the operator on the set-heading control display.

Phase 3—Automatic Position and Heading Control

Once heading of vessel has been set up correctly into the prevailing weather and at least one position measuring device has been deployed, automatic DP control can be selected. The DP system then controls the vessel's position and heading under closed-loop position control. The system will maintain the vessel's position within certain limits, until another DP position is requested. Changes of position can be achieved by using incremental push buttons. These enable the operator to move the ship in increments of 5 metres and 1 metre to a new reference point. When suitable conditions have been achieved the deployment of divers can take place.

During primary DP mode of operation. provision is made at the operator's console for an 'optimum heading' mode to be selected whereby ship's heading is continuously and automatically adjusted within predetermined limits to minimize propulsion power. Alarm indication will be given when the limits are reached.

The emergency controls on the left side of the control console operate via the emergency microprocessor similar to those explained above.

Auxiliary Modes—Tracking and DP

The integrated navigation system (INS) together with display and control facilities are mentioned in FIG. 1. This system uses information from surface and underwater navigational aids including EM and doppler logs, radio, and satellite navigation aids and compass to produce the best estimate of ship

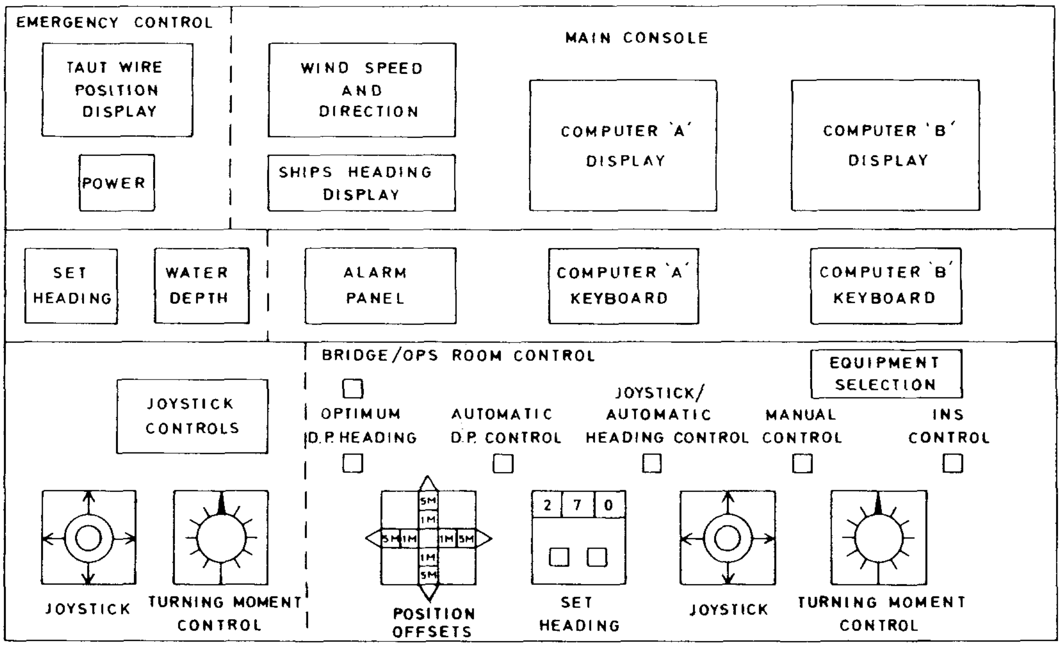

FIG. 9—THE DP CONSOLE

position. The navigation computer (again a GEC type 4070) is used to integrate the information and assess the true ship position prior to display, logging or implementation by the DP control system.

In the auxiliary modes of dynamic positioning and tracking, the control of the ship originates from the INS which operates through the DP system. When a mode of operation is selected at the INS console the necessary data is passed from the INS computer to the DP system computer.

For the auxiliary DP mode, the target DP position over a selected point on the seabed is chosen and the INS feeds the DP system with actual and target position data. The DP system then keeps the ship at the target position.

In the auxiliary tracking mode the vessel will automatically follow a predetermined track at a fixed speed and desired heading using INS information. This is achieved in a manner similar to the DP mode except that the target position is continually changed to form the required track.

No attempt is made here to include details of the INS hardware, control of submersibles, or diving arrangements because these aspects deserve separate treatment.

Summary

The DP system as described operates through the electro-hydraulic pitch-control system to maintain ship position without the use of moorings. The propulsion power is provided by the 3300-volt main supply system. This whole computer-controlled arrangement can then in turn receive data from another computer (INS) to allow track following, etc. to be achieved.

The descriptions contained in these three articles indicate the sophistication required to allow deployment of divers. In addition, the ship is built generally to commercial standards and to a tight budget. The result is a very challenging design, production, and commissioning task.

The shipbuilder has now reached the stage where test documents have virtually been completed and these systems are undergoing functional testing at the ship. There are, however, many hurdles to cross before ship acceptance in 1983. The procedure now will be to know the systems, highlight shortcomings revealed during testing, and resolve them in the given timescale. Functional adequacy, costs, programme, and quality standards all fit into this equation and the right solutions need to be found.

Acknowledgements

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