MACHINERY SURVEILLANCE IN THE FUTURE

BY

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Introduction

This article summarizes aspects of future machinery surveillance systems that will be of interest to those readers at the 'coal face' of modern warships. The first section explains the history leading to the present design paths. There is a description of secondary surveillance systems and alarm and warning systems. Then features of the design under development for the Type 23 Ship Control Centre (SCC) are described. Two other subjects are mentioned also: the use of closed circuit television for surveillance of machinery spaces, and the investigation of on board training equipment. In order to be brief and of general interest to all readers the article concentrates on functional aspects rather than technical details.

Background

During the 1970s there was extensive investigation into the potential future applications of digital processors to control and surveillance systems within the Royal Navy. It was encouraged by the rapid advances in industrial technology taking place at this time. Amongst other things, research showed that the use of distributed digital techniques offered better integrity and improved reversionary facilities than the existing analogue systems. Above all, digital systems would be more flexible. Provided modular software and high level languages are used software changes should be relatively simple to incorporate and the need for expensive replacement of hardware obviated. Thus the huge escalation in costs experienced whilst implementing the many modifications required on the control systems for the Type 42s and 21s should be avoidable.

A particular output from the research was a decision to differentiate between primary and secondary surveillance. Primary surveillance was defined as the information needed for the immediate operation of the machinery and is an essential ingredient of the permanent displays on the panels. The rest was classed as secondary surveillance, with access on demand being adequate.

The research led to two major developments: a distributed digital control and primary surveillance system known as Demonstrator, and the PASS (Propulsion and Auxiliary Secondary Surveillance) System which collected, processed, stored, and displayed the secondary information. These systems were constructed between 1979 and 1982 and then tested and evaluated at RAE West Drayton. The experience gained from these projects proved most useful during the early Type 23 studies. The technology, the principles, and the philosophies of the Type 23 control and surveillance systems reflect those developed during these two projects.

Another factor that has driven designers to extensive use of the latest control and surveillance system technology has been the constant desire, in common with many other navies, to reduce the complement of future ships. However, care is needed to ensure that the workload is minimized overall. It is no good fitting complicated equipment which provides a certain degree of automation or remote control but which then demands more of a higher skill level for maintenance. Design effort must be applied to assisting the maintainers. Reliability of equipments must be maximized so that defect maintenance requirements are minimized. Facilities to assist the maintainers with health monitoring and fault diagnosis must be considered for inclusion within the secondary surveillance systems. Intervals for planned maintenance must be compatible with mission times so that external work forces can be employed.

Secondary Surveillance

A secondary surveillance system will provide a major contribution to the reduction of the overall workload of the marine engineering complement in future ships. It is envisaged that the system will collect information on approximately 1000 parameters and provide output for the users in the Ship Control Centre. This will allow more diagnosis and monitoring to be undertaken from the SCC and enable the quantity of information required permanently on the consoles to be reduced considerably.

The information available on the system must be presented ergonomically. For example, reams of paper output are highly undesirable. The normal output would be on a Visual Display Unit with a printer being used for the main logs and wherever hard copy is required. A magnetic tape facility could be included but is unlikely to be cost-effective.

A major snag with the present Decca ISIS type system is that the automatic hourly print outs are difficult to use. The traditional log sheet with a day's worth of readings on one sheet has many advantages. In future systems the operator will be able, after 24 hours to call for a print-out of such a log sheet of the hourly readings for the day. He will then be able to review this log and file it for the requisite period with the minimum of effort.

A separate printer will be provided to record events and avoid the excessive paper output problem on the Decca ISIS systems. This will maintain a record of telegraph movements thereby removing the need for any manual recording of orders in the SCC. It will print alarm and warning events as has been done by Decca ISIS in the past. Also any operator action to inhibit warning channels, or in some cases to override certain parts of the control system (e.g. gas turbine starting interlocks), will be recorded.

If an operator wants to examine the state of an equipment he will be able to call for a display of the appropriate parameters on the Visual Display Unit. He could select a display of the current readings on the log or he might choose an appropriate parameter page which could resemble the example at FIG. 1.

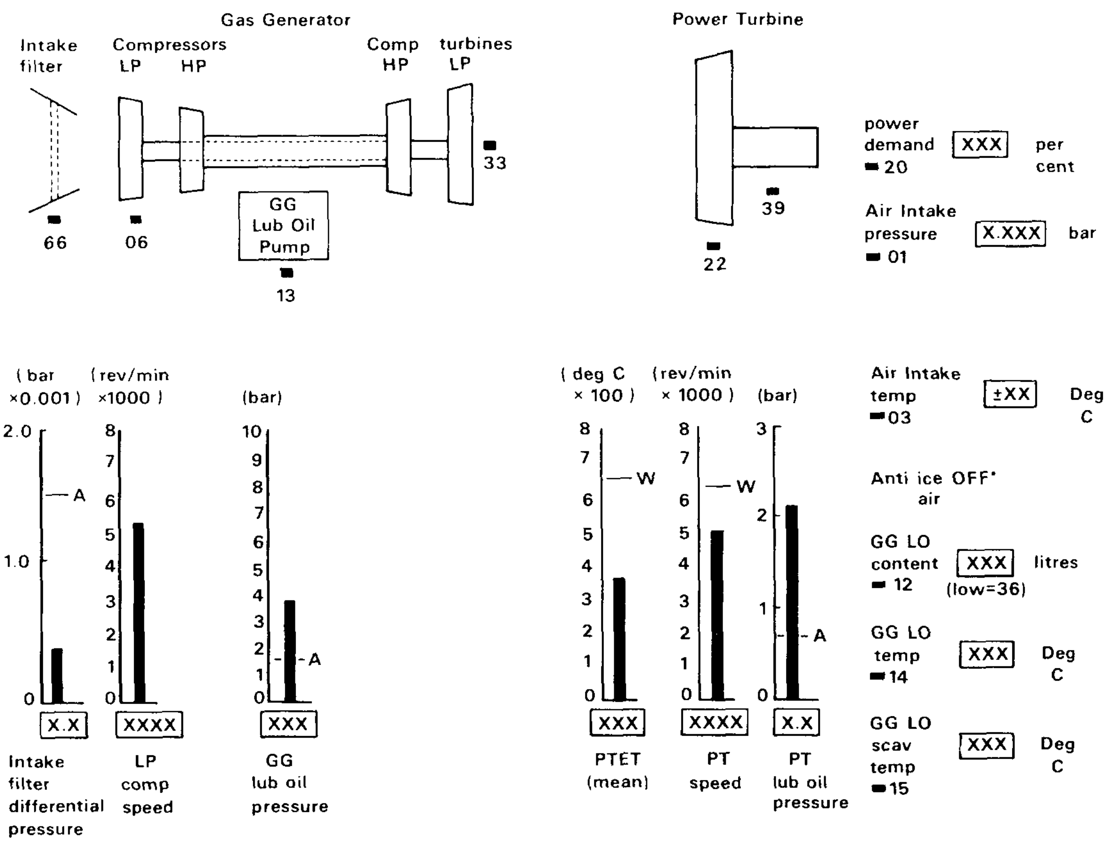

FIG. 1—TYPICAL VDU PARAMETER PAGE FOR THE SPEY GAS TURBINE
KEY: XXX : QUANTITY DISPLAYED ON VDU SCREEN
66 : IDENTITY NUMBER FOR CALLING UP SEPARATE DISPLAY OF QUANTITY

Other facilities within the system might make use of its processing ability. The task previously undertaken by Kollsman Life Recorders, recording gas turbine hours run and starts, will be possible within the secondary surveillance system. Likewise the system will be able to compile important statistics and derive key parameters. Basically it will provide direct access to parameters that would otherwise have to be computed manually. The system will enable users to extract graphs of parameters over the last half hour or the previous 4 hours. In this way operators will be able to examine trends and compare the behaviour of parameters. For example they might wish to look at a bearing temperature compared to shaft power over the last 4 hours. These facilities could assist maintainers with their health monitoring and help them obtain early warning of impending trouble.

An important page of information likely to be on display most of the time will be a list of the parameters currently in warning or alarm. When a group warning indication occurs, the operator's attention will be drawn by the audio-alert. He will see which group warning light is flashing and will then be able to establish the individual parameter responsible via the Visual Display Unit or the printer. He will be able to investigate further using his Visual Display Unit and ideally he should be able to establish the urgency of the action required without leaving the Ship Control Centre.

It is easy to envisage a computer system incorporating every desirable facility. The constraint is the cost-effectiveness of each facility, which must be judged by an assessment of its contribution to making the operators, maintainers, and supervisors more effective in their work.

Alarms and Warnings

Alarms draw attention to emergency situations requiring immediate attention, whilst warnings alert operators to matters requiring only early attention. The intention for the future is to minimize the number of alarm channels and to group warnings together. This avoids those in the Ship Control Centre being faced with banks of lights. The annunciation of alarms and group warnings and their display on the consoles is part of primary surveillance. The detailed listings and the printed records constitute secondary surveillance.

Alarms will be accepted by pressing the individual alarm's annunciator (lamp cover) on the upper area of the main console. Group warnings will be accepted by using a button low down on the vertical section of the panel containing the group warning concerned. Thus a group warning concerning parameters relevant to the propulsion panel will be accepted using the propulsion panels warning 'accept' button. Following Corporate experience, a 'mute' button will be provided also. When pressed this will mute or cancel both alarm and warning audio-alerts. The annunciating alarm or group warning lamp will continue to flash until accepted in the normal manner. Also it is intended to provide a key lock facility for this 'mute' button so that at action stations the Marine Engineering Officer has the option of eliminating the audio-alerts from the alarm and warning system.

Ship Control Centre

In the Type 23 the aim has been to achieve a well-integrated design for a single compartment combining the traditional roles of HQ1 and machinery control. In State 3 a three-man watch will be responsible for the main and auxiliary machinery control, electrical generation and distribution, and the traditional duties of HQ1. Meanwhile the same compartment must be effective for action stations with seven men. It is a difficult compromise. Most time will be spent in State 3 whilst there is no doubt that the design for State 1 is crucial.

Essential to the successful design of the compartment has been a static mock-up. Consideration of the various functions and priorities led to the overall configuration shown in FIG. 2. The left half of the main console will be allocated to NBCD displays including the main incident board. This half will include control and surveillance for some services such as the high pressure sea water, chilled water, and air systems, as these are important to NBCD. The right half will contain the propulsion panel, electrical generation and distribution panel, fuel supply panel, and the hotel services panel. In the middle of the compartment there will be a desk for the supervisors.

The detail of one part of the console is illustrated in FIG. 3. It will be seen that all status lights are positioned around the top of the panel, thereby enabling supervisors to grasp a situation from a quick top scan. Below these are the group warnings, and then the alarms. The number of lights and indeed the quantity of information on the panel has been minimized. For example only three analogue gauges are necessary for the gas turbine

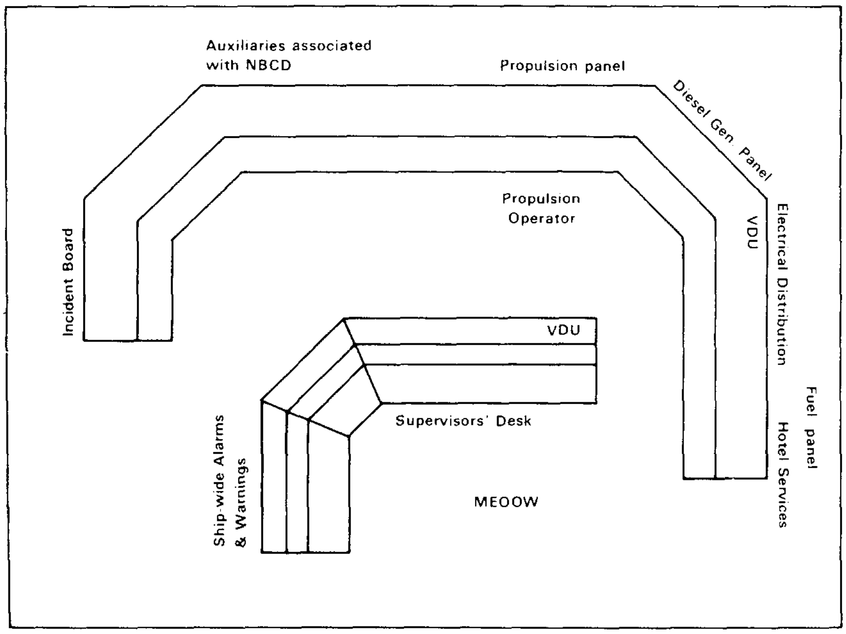

FIG. 2—LAYOUT OF A FUTURE SHIP CONTROL CENTRE

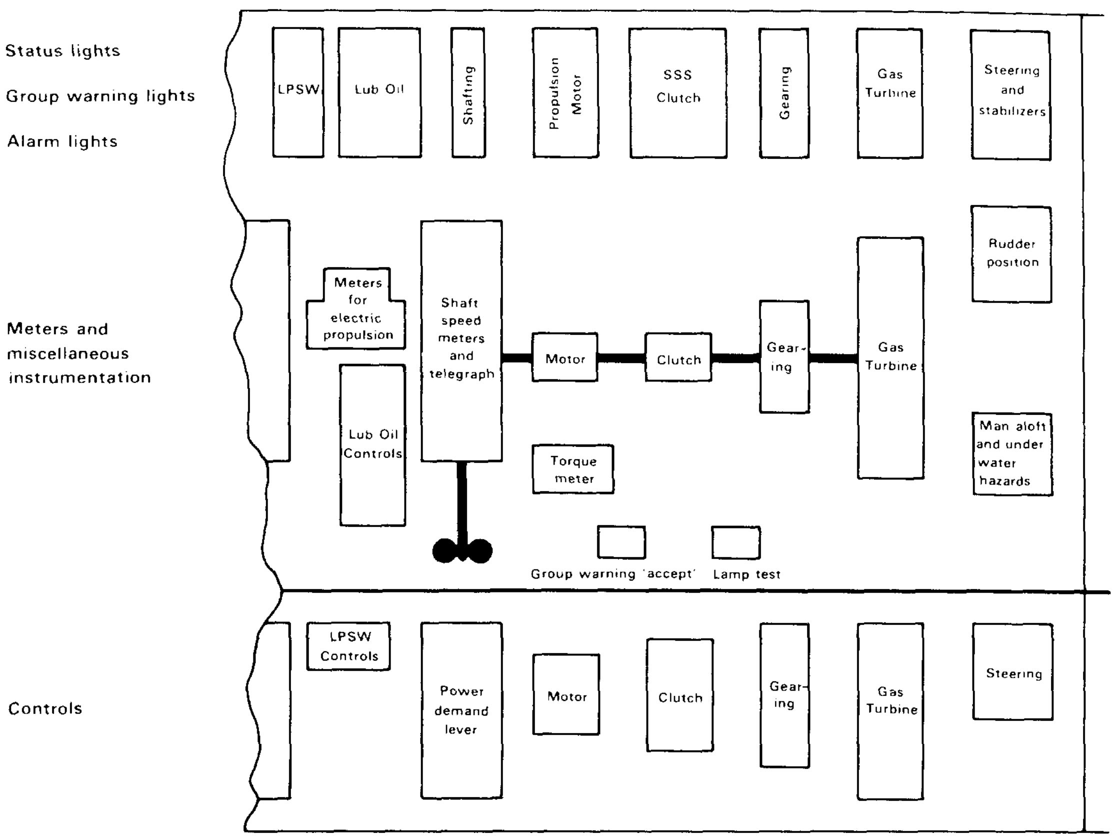

FIG. 3—LAYOUT OF THE PROPULSION PANEL IN THE SHIP CONTROL CENTRE

parameters. The alarms are positioned so that they can be reached (and accepted) by a seated operator. The diagrammatic shaft and propeller provide a visual link between the vertical blocks of instrumentation. The right angle bend in the shaft occurs because the overall layout was governed by the spacing of the Power Demand Levers and the central positioning of key instrumentation for ergonomic reasons.

The central parts of the panel provide the key instrumentation and telegraphs essential to the operation of the electric propulsion motors. As most of the time will be spent in electric drive, the three relevant gauges are positioned directly in front of the operator's eyes. The actual levers and buttons providing control are on the bottom panel. Thus control of the main propulsion should be relatively simple. Complications have been avoided by moving all inhibits and overrides, such as the start interlock overrides for gas turbines, on to the supervisors' panel.

From the supervisors' desk the Marine Engineer Officer of the Watch will have a good all round view of the Ship Control Centre. In State 3 he will be able to monitor the left-hand panels as well as the propulsion areas, whilst in State 1 he will be able to concentrate on the machinery and electrical distribution.

The effectiveness of communications in State 1 is recognized as a problem area and is under investigation. With two broadcast systems and seven people all talking together, the noise level could cause difficulty. A possible solution is to use open lines and headsets in State 1, rather than the broadcast systems, and adopt procedures similar to those used in Operations Rooms.

On Board Training

It has been suggested that on board training might be achieved by incorporating into the SCC a facility capable of simulating the main propulsion. This would make the controls and surveillance in the SCC mimic the behaviour of the real systems, both in indication and response, so as to enable personnel to be realistically trained. It should be possible to design the system so that the actual machinery could continue to be operated from another control position whilst training is in progress. A preliminary study has concluded that the idea is feasible but that there are many problems to be overcome. The main difficulty is likely to be switching from one system to another without degrading the reliability of the control system.

Closed Circuit Television for Machinery Spaces

One possible way of assisting operators is to provide surveillance for the machinery spaces by closed circuit television. This may be able to help in the following ways:

(*a*) Assessing local conditions within unmanned machinery spaces after damage.

(*b*) Giving the MEOOW immediate and positive evidence following a fire alarm.

(*c*) Allowing men locally to point out problems to the MEOOW in the control room, allowing him to make a better remote assessment.

(*d*) Supervising inexperienced watchkeepers.

(*e*) Keeping a general eye on unmanned machinery spaces, thus aiding security against fire, flood, and sabotage.

Two television systems have been installed for evaluation in the After Auxiliary Machinery Room and the After Engine Room of H.M.S. *Nottingham*. They are being assessed against the likely manpower in future ships. A particular problem foreseen is that manning levels will be such that the MEOOW will be unable to leave the SCC. Thus the supplementary surveillance information offered by the closed circuit television could be extremely valuable.
