TYPE 23 MACHINERY CONTROLS AND SURVEILLANCE SHORE TRAINING FACILITIES

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ABSTRACT

The Type 23 Machinery Controls and Surveillance shore training facility simulates the behaviour of the ship systems and their D86 controls. The Ship Control Centre consoles are linked to local control outstations. The instructor injects initial conditions, external conditions and malfunctions. Operating and fault-finding training can be provided.

Introduction

The Type 23 frigate Machinery Controls and Surveillance (MCAS) Shore Training Facilities will be installed in H.M.S. *Sultan* and ready for use by the end of 1988. They are being produced by Rediffusion Simulation Ltd., who won the contract as a result of competition. The facilities are designed to provide Pre-Joining Training for the marine engineering crew (and particularly the Ship Control Centre (SCC) watchkeeping personnel), Continuation Team Training, Aquaint Training for officers and maintenance training for Type 23 controls maintainers. The facility will be ready for training the marine engineering crew of Type 23 01, and the requirement for a life of 30 years of the equipment is designed to accommodate all future training needs.

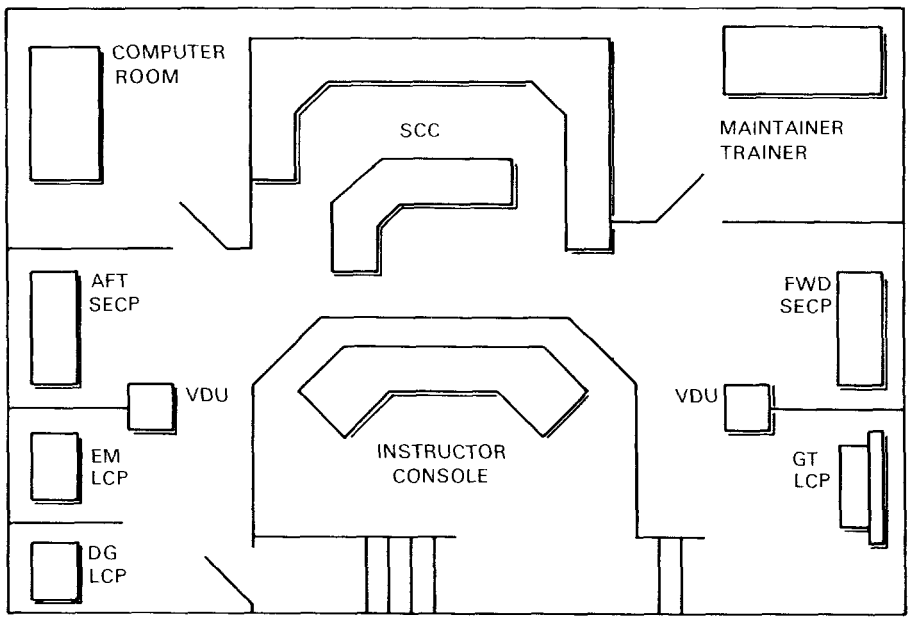

FIG. 1—TYPE 23 MACHINERY CONTROLS AND SURVEILLANCE TRAINER
DG LCP: diesel generator local control panel
EM LCP: electric motor local control panel
GT LCP: gas turbine local control panel
SCC: Ship Control Centre
SECP: secondary electrical control panel

Overview

The training facilities, as shown in FIG. 1, consist of the following:

(*a*) Instructor console.
(*b*) SCC Operator and Supervisor consoles.
(*c*) Local Control Outstations—DGLCP, GTLCP, Fwd SECP, Aft SECP, EMLCP (abbreviations are explained in the key to FIG. 1).
(*d*) Maintenance Training Facility.
(*e*) Classroom Training Aids—active mimic panel, back projection screen.

Simulations

Ship systems are simulated using a Gould 32/67 Concept computer. All relevant systems are simulated and most are covered by full simulation. This means that system characteristics are faithfully reproduced so that the correct operating characteristics are portrayed with precise parameter values. Full simulation also means that the correct knock-on effects of any injected fault will be experienced if corrective action is not taken by the trainee operators. A few systems are subject to 'approximate' simulation, which means that the computer module will reproduce the correct operating characteristics of the system, but parameter values will be approximate only. Systems thus covered are those for which parameters are not directly displayed on the training equipments (e.g. stabilizers, HP Air). The lowest form of simulation used is 'partial' simulation where it is necessary to provide certain parameters to support control of logic, instrument readings or other indications, but the systems themselves need not be simulated. Such systems include the NBCD system, ventilation system, sewage system, and refrigeration system. It may be noted that the policy to retain only sufficient simulation of NBCD systems to allow training in the 'first aid responses' of the SCC watch keeping crew to NBCD incidents has been maintained for Type 23 training.

SCC and Outstations

The SCC consoles and Outstation Local Control Panels (LCPs) are all items which look and work precisely like the ship fitted equipment. This includes the secondary surveillance facilities fitted in the SCC consoles. However, being driven by simulations, they contain no relevant ship equipment inside the consoles or panels.

The Outstation LCPs (with the exception of the Secondary Electrical Control Panels (SECPs)) can be configured to portray any of the actual LCPs in the ship, by means of control at the Outstation VDUs. Thus the DGLCP is allocated to portray any one of the 4 DGLCPs by the trainee operator at an Outstation VDU before he continues to exercise any control at the LCP (and similarly for port and starboard GTLCPs, and port and starboard Electric Motor LCPs).

The Outstation VDUs provide access to other relevant ship equipments or systems not already covered. These comprise:

(*a*) Fuel boost system.
(*b*) Fuel transfer system.
(*c*) Low Pressure Sea Water (LPSW) system.
(*d*) Main lub oil system.
(*e*) Gearbox LCP and manual control.
(*f*) Shaft brake local control.
(*g*) One chilled water plant LCP.
(*h*) Diesel generator (DG) AVR 600/440 V change-over switches.

Each of the systems covered provides system schematics, with salient features operational. The outstation VDUs are operated by Touch Activated Screen Control (TASC), so an operator merely touches a valve to change its state from open to shut or vice versa. Reconfiguration of the systems provided is therefore possible. Gearbox controls allow LCP or 'manual' operation of the SSS clutches and control of transient brake isolating and control valves. Local operation of shaft brakes is accommodated, and limited control of one chilled water plant LCP is available. The DG AVR change-over switches are necessary to enable alternative 440 V operation of the two DGs which can be used to serve the 440 V system directly.

Instructor Facilities

The instructor facilities are provided at the console in Fig. 1, which is sited on a raised platform behind one way glass. The console is designed to be operated either by only one instructor or by two instructors (which could be necessary during Continuation Team Training). Control of exercises is conducted via either of two 19 inch VDUs, both operated by Touch Activated Screen Control. Each TASC VDU has an accompanying panel of 24 push-buttons for first level control. Also provided at the console is a replica secondary surveillance Plasma Display for the instructors' own information purposes, a bridge telegraph control unit, and communications systems controls.

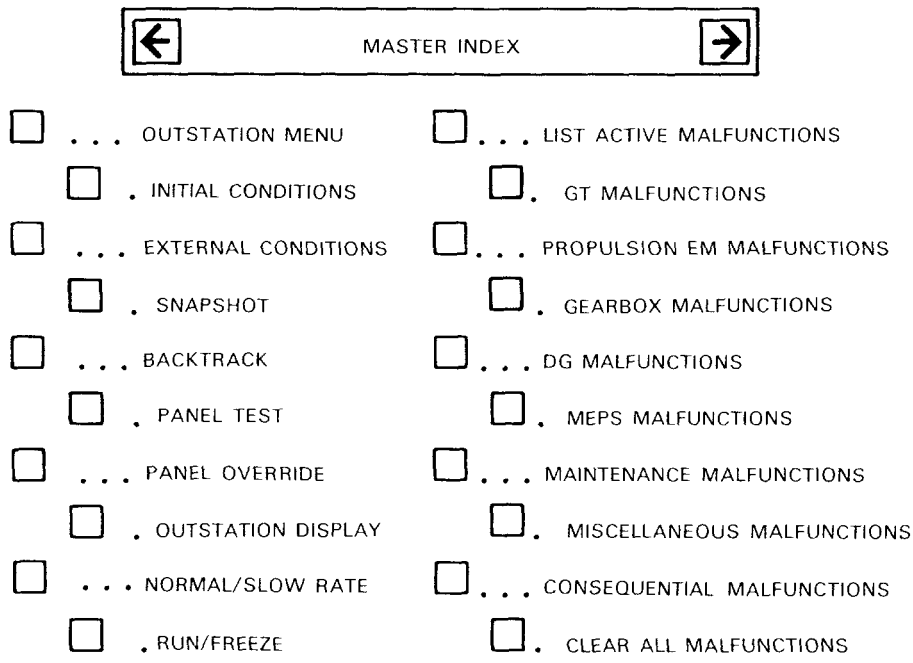

FIG. 2—INSTRUCTOR MASTER INDEX PAGE
MEPS: main electrical power system

The Master Index on the instructor TASC VDUs is shown in Fig. 2. Provision of two monitors clearly allows excellent flexibility for one instructor, and is vital when two instructors are running an exercise. By selecting 'Outstation Menu', the instructor has access to the Outstation VDU facility. Selection of 'Outstation Display' simply reproduces the screen display of the Outstation VDUs, enabling the instructor to monitor the actions of a trainee operator at the Outstation VDU with ease.

To start an exercise, any one of ten Initial Conditions can be selected. Should control settings on the SCC consoles or Outstations differ from those of the selected condition, a discrepancy report is available from the instructor VDU to enable rapid configuration of the physical items.

'External Conditions' allow a variety of external factors to be adjusted (e.g. Sea State, ambient air temperature, ship electrical load, shore supplies (available/non-available), GT intake icing (present/absent), towed array (deployed/stowed)). 'External Conditions' also includes a variety of reset facilities for the instructor, allowing rapid restoration of facilities following an exercise (e.g. reset modules' Halon drench, reset of tank levels, reset of electrical distribution system to 'normal' operation).

The snapshot facility allows the state of the simulator to be stored for future use, either for de-brief purposes or as an additional exercise start point.

The back-track facility allows the last 30 minutes of exercise 'play' to be replayed in steps of one minute intervals. At any point, the exercise can be 'frozen' by means of the run/freeze control, and the simulations can also be slowed down to 1/5 of the normal real time rate by means of the normal/slow rate control.

TABLE I—*Panel overrides*

Port & stbd PDLs	DG1 start button
Port & stbd GT trip levers	DG2 start button
Port & stbd EM breakers	DG3 start button
Port & stbd transient brake controls	DG4 start button
Port & stbd shaft brake controls	DG1 stop button
Port & stbd CODLAG drive select buttons	DG2 stop button
Port & stbd EM drive select buttons	Fwd M/G 440V ICB
Port & stbd EM power available indications	Aft M/G 440V ICB
Port & stbd EM bias controls	Fwd 600V ICB
No. 1 CW Pump start button	Fwd DG alt 440V ACB
No. 1 CW Pump inlet open button	No. 1 HPAC start button
No. 1 HPSW Pump start button	No. 1 LPAC start button

Key—ACB : air circuit breaker
CW : chilled water
DG : diesel generator
EM : electric motor
GT : gas turbine
HPAC : high pressure air compressor
HPSW : high pressure sea water
ICB : interconnector breaker
LPAC : low pressure air compressor
M/G : motor generator
PDL : power demand lever

Panel overrides are provided for those items listed in TABLE I. If the instructor selects 'Panel Overrides' from his Master Index, he is presented with a display shown in FIG. 3. Touching the relevant area of this display will select the relevant list of overrides available; thus touching the 'PROPN' area will generate the display shown in FIG. 4. The instructor then touches the box (or boxes) he wishes to select. By touching the area marked 'INSRT' he will then activate the selected override(s). Overriding the port PDL, for example, will render the port PDL on the SCC Operator console inoperative. The signal from the port PDL will remain at the latest setting, and the operator will have to exercise control at the outstations.

Malfunctions that can be injected by the instructor are split into seven groups as shown in FIG. 2 and the complete list of all the malfunctions is contained in TABLE II. Four sets of 'Consequential Malfunctions' are also available. These are pre-programmed sequences of malfunctions, designed to provide examples of major catastrophes.

TABLE II—*Type 23 Trainer malfunctions*
(** indicates that malfunction can be applied to port and starboard items*)

Gas Turbines

Hot start*
Fail start*
Starter fails to disengage*
High module temperatures*
Fire*
GT speed falls below idle*
FSC freeze*
PTET warning*
Spurious trip*
PT LO pressure low*
GGLO differential pressure low*
FSC goes to maximum*
Air intake depression high*
Port GGLO tank level low
Stbd GGLO temperature high
Port PT main thrust brg temp high
Stbd PT rear journal brg temp high
Port gas generator front vibration high
Stbd PT vibration high

Gearbox

MDFL pump No. 1 fail
MDFL pump No. 2 fail
MDFL pump No. 1 fail to cut in
MDFL pump No. 2 fail to cut in
ADLO pump fail to cut in
Main LO pressure low
Gearbox belt driven pump fail*
LO control point temp high*
SSS clutch fails to disengage*
SSS clutch fails to engage*
SSS clutch baulks*
Transient brake fails to release*
Port GT pinion fwd brg temp high
Port main wheel aft brg temp high
Stbd GT pinion aft brg temp high
Stbd output shaft aft brg temp high
Stbd GT pinion fwd brg vibration high
MGR Plummer block temp high*

Diesel Generator

(**indicates malfunction can be applied to all four DGs*)
Induction manifold air flap vv shuts*
Spurious electrical trip*
LO pressure low
LO temp high*
Coolant pressure low
DG 3 & 4 coolant temp high
DG fail start*
DG 1 & 2 fire
Exhaust scatter high*
One speed sensing signal failure*
Fuel header tank level low*
LO priming system u/s*
DG overfuel*
DG underfuel*
Main breaker trips*
AVR failure*
Generator excitation fault
Air temp to generator cooler high

Miscellaneous

Fuel—No. 1 fuel service tk level low
No. 2 fuel service tk level low
No. 3 fuel service tk contaminated
No. 1 Boost pp discharge pressure low
No. 2 Boost pp discharge pressure low
No. 3 Boost pp discharge pressure low
LP fuel vv fails to shut*
FAMR coalsecer diff pressure high
Aft fuel centrifuge fail
Fwd fuel centrifuge fail
Aft fuel transfer pp fail
Fwd fuel transfer pp fail

CW—MGR CW plant fail—SW pp OOA
MGR CW plant fail—compressor fault
MGR CW plant fail—CW pp OOA
Fwd ringmain supply flow low
Fwd tracker office flow low
Ops Room Annex flow low
Sonar 2031/182 space flow low
Aft ringmain supply flow low

HPSW —HPSW pp No. 1 fail
HPSW pp No. 2 fail
HPSW pp No. 3 fail
HPSW pp No. 4 fail
HPSW pp No. 5 fail
HPSW pressure low Port
HPSW pressure low Stbd
Low SW flow to UAMR

LPSW —All LPSW pumps fail

HP Air—No. 1 HPAC fail
No. 2 HPAC fail
GTR HP Air ring main pressure low

LP Air —No. 1 LPAC fail
LP Air fwd ring main pressure low

Vent —FAMR Port supply vent fan trip
UAMR Stbd supply vent fan trip

FW —Fresh Water CFW pp No. 1 fail
Fresh Water CFW pp No. 2 fail
Fresh Water HPW pp No. 1 fail
Fresh Water HFW pp No. 2 fail

Desal —Desalination plant No. 1 fail
Desalination plant No. 2 fail
Desalination plant No. 3 fail

Refrig —Refrigeration plant No. 1 fail
No. 1 Cool room temp high

Steering—Steering pp No. 1 fail
Steering pp No. 2 fail
Steering header tk No. 1 level low
Steering header tk No. 2 level low

NBCD —Fire in UAMR
Fire in FAMR
Fire in GTR
Fire in MGR
Fire in Fwd Swbd Room
Flood in GTR
Flood in MGR
Flood in Avcat pp space
Door opened/closed Zone 2–3
Door opened/closed Zone 3–4

TABLE II (contd)

MEPS

Fwd M/G 600V ACB fail
Aft M/G 600V ACB fail
Fwd 600V ICB fail
DG 1 alt 440V ACB fail
DG 4 alt 440V ACB fail
Fwd M/G fail (loss of SW cooling)
Aft M/G fail (loss of SW cooling)
Fwd M/G fail (AVR fault)
Aft M/G fail (AVR fault)
Fwd auto power sharing fail
Aft auto power sharing fail
Fwd auto load shedding fail
Aft auto load shedding fail
Fwd check synch fail
Aft check synch fail
Fwd auto synch fail
Aft auto synch fail

Maintenance

MGR port CDCU fault
MGR stbd CDCU fault
MGR port CDCU failset
MGR stbd CDCU failset
GTR port CDCU fault
GTR stbd CDCU fault
GTR port CDCU failset
GTR stbd CDCU failset
FAMR DCU fail
SCC CDCU failset
Fwd SECP serial data link fail
Aft SECP failset—CPU fail

Propulsion EM

Converter ACB tripped*
Demand signal error*
No. 1 fan failure*
No. 2 fan failure*
Loss of regulator field weakening circuit*
Port armature fuse ruptured
Stbd field current imbalance
Thyrister control failure*

Key—ACB : air circuit breaker
ADLO : air driven lub oil
AVR : automatic voltage controller
CW : chilled water
DG : diesel generator
EM : electric motor
FAMR : forward auxiliary machinery room
FSC : fuel system controller
GGLO : gas generator lub oil
GTR : gas turbine room
HPAC : high pressure air compressor
HPSW : high pressure sea water
LO : lub oil
LPAC : low pressure air compressor
MDFL : motor driven forced lub
M/G : motor generator
MGR : motor generator room
OOA : out of action
PTET : power turbine entry temperature
PTLO : power turbine lub oil
SCC : Ship Control Centre
SECP : secondary electrical control panel
SW : sea water
UAMR : upper auxiliary machinery room

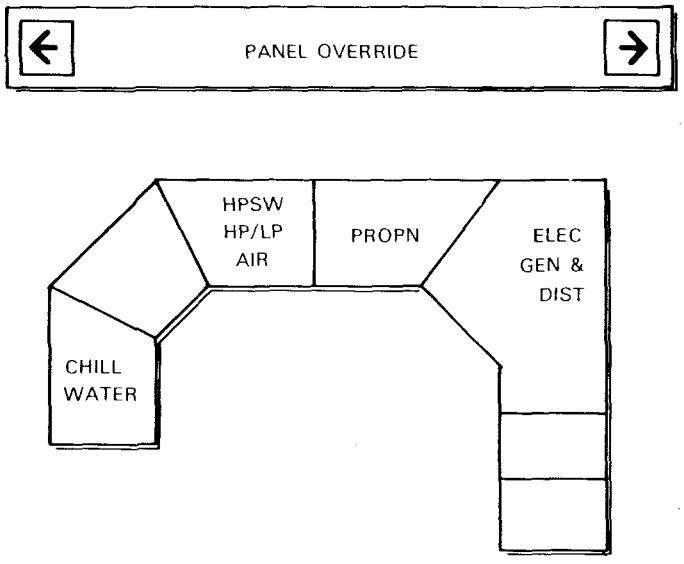

FIG. 3—PANEL OVERRIDES MENU

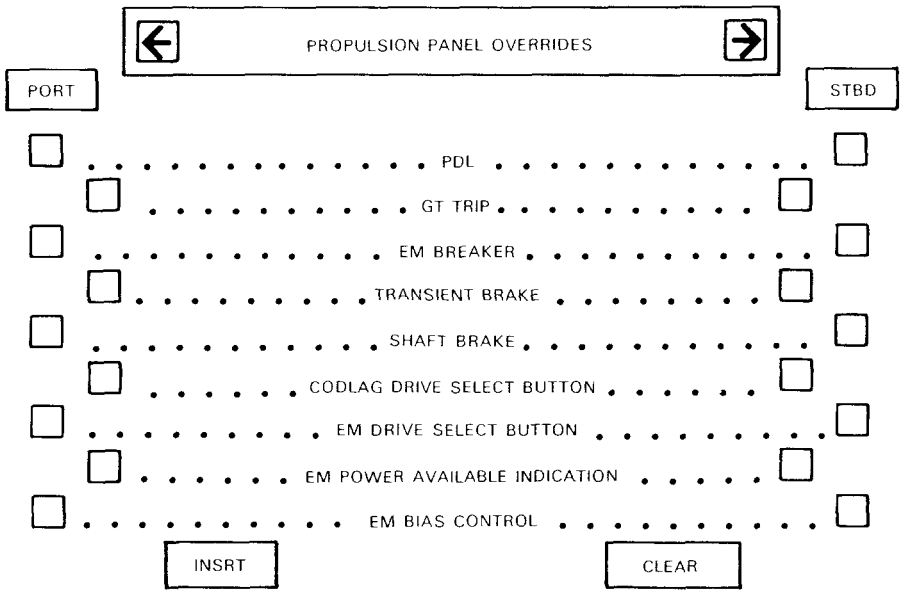

FIG. 4—PROPULSION PANEL OVERRIDES. INSTRUCTOR TASC PAGE
PDL: power demand lever
TASC: touch activated screen control

The training facilities also include a portable control unit for use by the instructor. This unit allows control over the salient functions of the instructor facilities. It is a small hand-held unit which is stowed in the SCC area and thus allows the instructor to run through a de-brief session in the main training arena without having to return to his console to activate his controls (e.g. back-track, snapshot, etc.).

Communications System

A comprehensive communication system is provided with the training facilities. It provides 'eavesdrop' facilities for the instructor as well as replication (or simulation where appropriate) of the range of communications available on board.

Maintenance Training Facility

The maintenance training facility (FIG. 5) comprises a Regency microcomputer with two display screens. It has two basic modes of operation: fault finding and instructor-led training. The primary function of this training

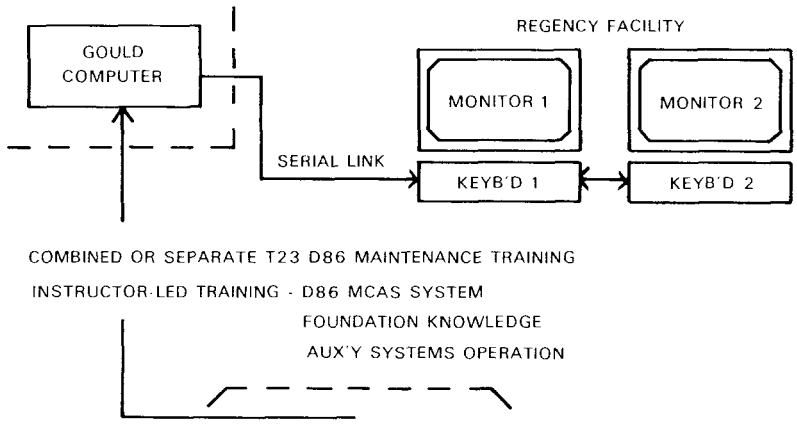

FIG. 5—MAINTENANCE TRAINING FACILITY

facility is the exercising of the trainees' fault-finding skills. The Regency software is designed to produce high resolution graphics representations of the Type 23 D86 units, and allow logical fault investigations through interaction with the 'equipment' using Touch Screen Activated Control facilities. This mode of operation is sub-divided into 'combined' mode fault finding and 'separate' mode fault finding.

In the combined mode, the maintenance trainer is linked to, and under the control of the main simulator computer. The link is effectively one way, from Gould to Regency. This enables the instructor to select one of the combined mode faults (see TABLE II) causing both the simulator and maintenance trainer to manifest the symptoms of that fault. Trainee operators can take action to accommodate the fault whilst maintaining control, and the maintainer trainee can devote his attention to locating the faults. The structure of the Regency software portraying the D86 system is such that whilst the maintainer trainee follows his diagnostic procedures, the D86 network structure is also reinforced in his mind.

Separate mode fault finding operates independently of the main simulator. The list of faults in TABLE III, available for selection at the Regency, are purely for training with the Regency System. Design has been such that these separate mode faults can readily be expanded as experience is gained from the Fleet.

TABLE III—*Regency Maintainer Trainer separate mode malfunctions*

Alarm Logic Rack fault	Contact faulty
Alarm Logic Rack failure	Diagnostic PCB failure
MMI Rack failure	Power supply unit failure
MMI Rack failure	Speed peripheral PCB failure
Comms Unit failure	Comms link failure
FAMR DCU fault	Output wiring fault
SCC CDCU failset	Memory PCB failure
SCC DCU failure	Analogue input PCB failure
Alarm Logic Rack failure	CPU failure
SCC DCU fault	Transducer fault
DG LCP failset	Relay PCB failure
DG LCP failset	Diagnostic PCB failure
DG LCP change in logic	Time constant altered
CW LCP failure	I/O Interface PCB failure
CW LCP change in logic	Temperature limit altered
CW LCP fault	Signal out of bounds
PECP failure	Motherboard failure
PECP failure	AC parameter PCB failure
PECP failure	Buffer PCB failure
PECP fault	Serial data signal outside range

Key—CDCU: control and data collection unit
CW : chilled water
DCU : data collection unit
FAMR: forward auxiliary machinery room
MMI : man machine interface
PCB : printed circuit board
PECP : primary electrical control panel

In either mode, the Regency displays all the Type 23 D86 units, and the various diagnostic tools (e.g. 16-character handsets). The Regency also displays all relevant secondary surveillance messages that are associated with an injected fault—this provides both secondary surveillance Plasma messages and event printer messages. Fault finding to individual board level is provided, and faulty PCBs are removed and replaced using the touch screen control. Fault-finding activity with items external to the D86 system is available (e.g. wiring faults, transducer faults), and design of the Regency software is intended to reflect and complement the diagnostic Books of Reference that will be produced for use in the Fleet.

Instructor-led training utilizes the comprehensive Regency facility to provide enhanced classroom training. The module is designed to operate with the back projection screen, providing a large screen display of the Regency display(s) for use in the classroom. The courseware provides animated sequences under instructor control via the Regency touch screen to enable display of the functional aspects of the Type 23 D86 control and surveillance system. It also includes an example of a 'Foundation Knowledge' module and the operation of the Fuel Boost System. These latter modules are provided as blueprints for use by H.M.S. *Sultan* staff to produce further modules in-house. These further modules will be created on independent discs thus not affecting the material supplied by Rediffusion. The 'Foundation Knowledge' example will provide familiarization training in the layout of machinery in the Motor Generator Room. An animated fuel boost system schematic is provided which can be reconfigured to portray the various modes of operation of the systems.

The overall design of the maintenance training facility represents a new style of maintenance training and classroom training for H.M.S. *Sultan*. In the maintenance training mode it attempts to portray the fine detail of D86 malfunctions. These factors mean that fine tuning will be inevitable, as experience and feedback is forthcoming from the operational Fleet. Thus care has been taken to ensure that overall design of the facility is such that future modifications can be accommodated without difficulty.

Classroom Training Aids

Classroom Training Aids comprise an active mimic panel and a back projection screen. Both items are linked to the other training facilities as shown in FIG. 6. The back projection screen can be used to display either of the Regency screen displays. It can also accommodate input from a video source, which is likely to be of use in the future.

The active mimic panel displays a representation of one shaft line, the electrical generation and distribution systems, and the D86 control and surveillance systems. It can be operated in two modes, local and remote. In remote mode, the mimic is driven by the Gould computer and reflects the state of the main simulator and thus any operations being exercised. In local

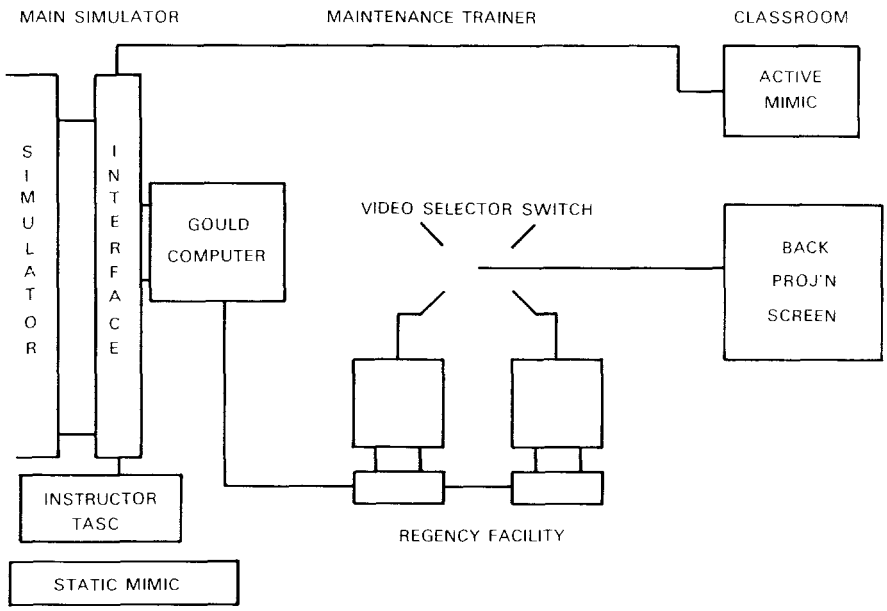

FIG. 6—CLASSROOM TRAINING AIDS

mode there are two types of operation. Firstly, a number of switches can be activated to display the different types of D86 surveillance signals. Secondly, the sequence of events can be displayed, showing the salient aspects of Type 23 main machinery operation. The sequence is driven by inputs from the Gould computer, but can be run concurrently with training exercises in the main simulator (i.e. the Gould computer must be 'on', but operation of the mimic will not effect operations in the trainer).

Provision of the active mimic in the training facilities has allowed provision of a static mimic panel at minimal cost. The static mimic is merely a non-functional replica of the active mimic, and will be sited in the instructor booth for display purposes.

Conclusion

Although the Type 23 Frigate Machinery Controls and Surveillance Shore Training Facilities broadly follow the traditional type of equipments provided in the past, they benefit from use of the latest training technology, and display some interesting new features. It must be noted that the maintenance training element is supported by other equipments destined for H.M.S. *Sultan* to train maintainers of D86 systems, and thus the reliance upon microprocessor-based training for the specific Type 23 application is justified.