CUTHBERT IN 'EXMOUTH'

BY

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In the July, 1970, issue of the Naval Electrical Review *an article entitled 'An Advanced Automatic Pilot and Electric Steering System for Military Ships' described the steering system being fitted in new construction ships. The following article describes the prototype of the equipment, fitted in H.M.S.* Exmouth *for evaluation. H.M.S.* Exmouth, *which is certainly the Western World's first all gas turbine powered, auto-pilot fitted major warship, has just completed a short refit after being deployed operationally in home waters and in the Mediterranean.*

Introduction

The electric steering and automatic pilot, nicknamed 'Cuthbert', was fitted in H.M.S. *Exmouth* (ex H.M.S. *London*) during May, 1969. The automatic pilot was fitted on the bridge. The electric steering system was coupled to the end of the floating link in the hunting gear of the normal Admiralty Mk 1 hydraulic steering gear. Emergency electric steering control is possible from the aft control switch panel in the tiller flat in the event of a break in the cables from the bridge console.

S. G. Brown Ltd. produced the system, though certain units were sub-contracted to A.E.I., Ministry of Defence (DG Ships) representatives from Bath and S. G. Brown Ltd. supervised the installation which took place in Chatham Dockyard.

The first experiences at sea were not too encouraging and trouble was experienced with the power supply unit (inverter) in the tiller flat. The problems were eventually only rectified by replacing the unit in July, 1969. Since that time the system has been run for about 1700 hours, the longest continuous period being 170 hours.

Initially there was a certain period of adjustment required while the more conservative naval officers changed from an attitude of outright suspicion to one of endearment. This process occurred very quickly and it was not long before the system was accepted and became known as Cuthbert. The speed with which Cuthbert was accepted is not surprising when some of the advantages are considered. For example, on leaving harbour the steering is always changed from hydraulic to electric. The wheelhouse crew of quartermaster and boatswain's mate are then not required to close up, though the latter is usually retained to run ship's routine and act as lookout. This means that a total saving of eight men can be made. This fact in an age of bad recruiting figures has obvious merits.

Another advantage lies in the way that Cuthbert contrives drastically to reduce the noise level on the bridge. Instead of the normal verbal exchanges between officer of the watch and quartermaster, alterations of course merely require the turning of a dial to the selected course. This is of even greater value during anti-submarine exercises. The officer of the watch needs only to dial the course ordered by the Command. He can then concentrate on the multitude of other tasks he has to complete at the same time, as there is no requirement to 'conn' on to the new course. In addition he does not have the problem of attempting to listen to the conning intercomm at the same time as he is trying to hear the next alteration of course from the Command, all of which makes his job much easier.

Cuthbert has been used for a replenishment at sea and not only performed satisfactorily but managed to make it one of the quietest replenishments on record. The only problem now is controlling the vast noisy hordes of ships company who congregate on the bridge to watch this miracle of modern science at work!

The System

H.M.S. *Exmouth* is now fitted with two separate steering control systems. The first is the conventional Admiralty hydraulic telemotor system where rudder demand is fed hydraulically from the wheelhouse to a telemotor receiver. The receiver causes offset on the swash plate of the steering motor pump which in turn supplies hydraulic power to the rams which move the rudder. Reset (hunting gear) on the rudder head controls the positional accuracy. The second, the new electrical system, transmits a rudder demand as an electrical signal to the control panel of a separately excited d.c. motor. This motor drives via rack and linkages to move the swash plate of the steering motor pump in the same way as the telemotor system. Position of the rack is controlled by a reset transmitter on the rudder head. The rudder itself is controlled by the reset (hunting gear). The electrical rudder demand signal comes from the auto-pilot on the bridge, either put on manually as a set rudder demand or automatically when a new course is dialled.

A schematic of both systems is shown in FIG. 2.

The diagram shows that selection of system is carried out via a lever in the wheelhouse. In position 1 the electric system is isolated and the telemotor

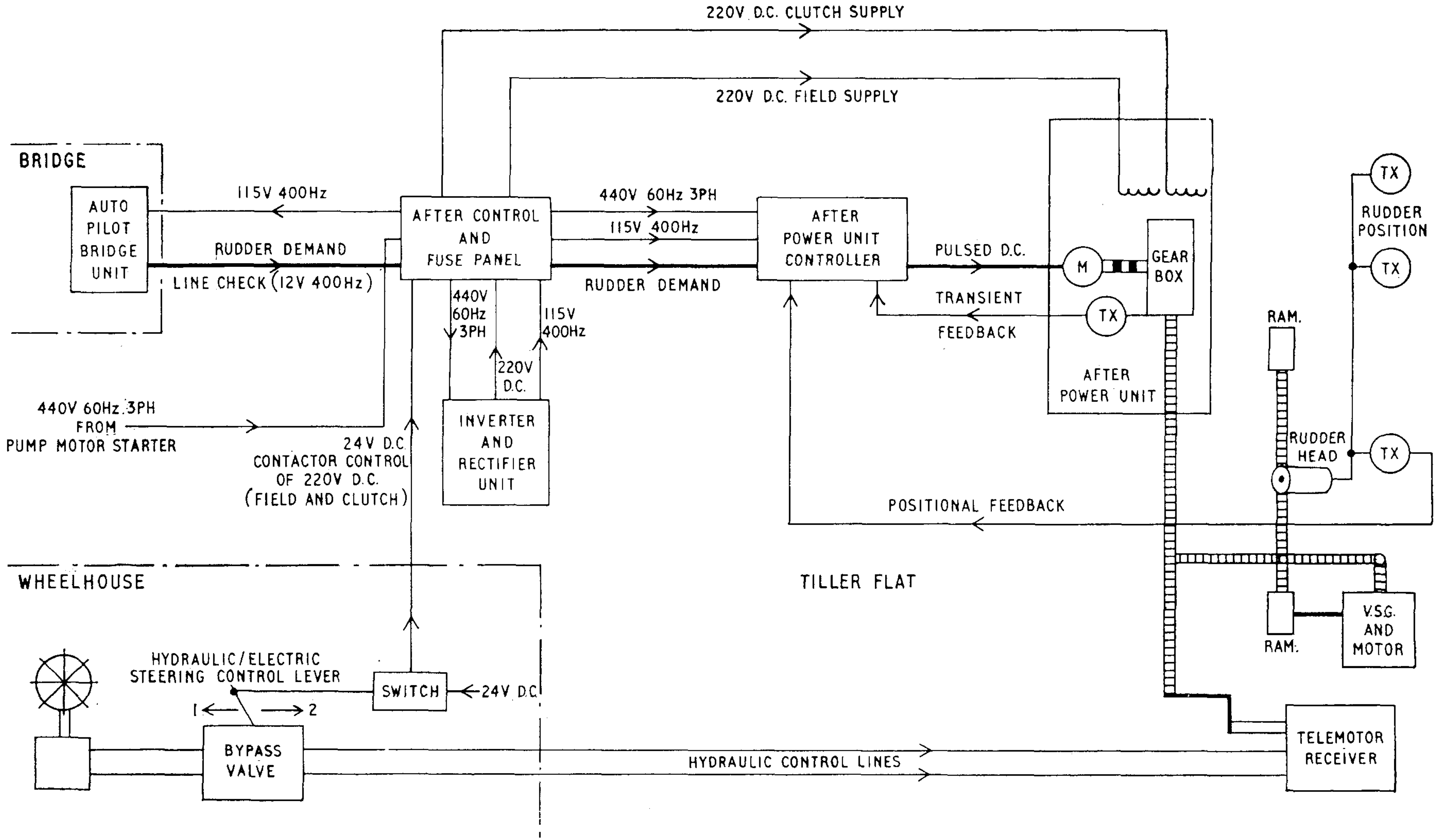

FIG. 2—SCHEMATIC DIAGRAM OF THE ELECTRIC STEERING SYSTEM

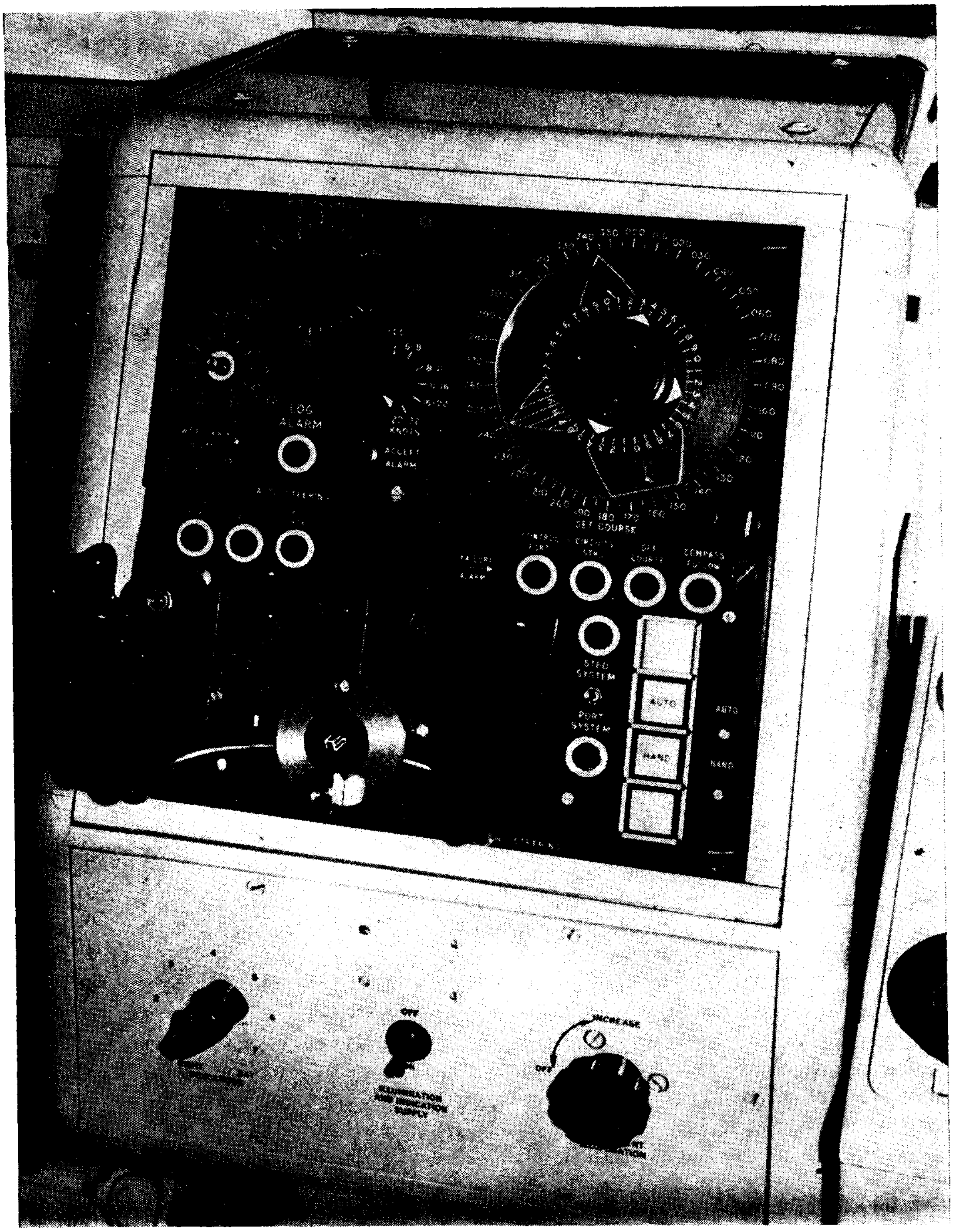

FIG. 3—THE AUTO-PILOT

system is in control. On ordering a change to electric steering the hydraulic and electric wheels are put to midships. The lever in the wheelhouse is then moved to position 2. This opens by-pass valves which isolate the telemotor system and at the same time closes a micro switch which connects the ship's 24-volt supply to a contactor in the aft control switch panel supplying 220v d.c. to the APU motor field and clutch. The aft control switch panel also feeds 440v, 60 Hz, 3-phase to the inverter (power supply unit), which produces 115v, 400 Hz for the control system.

The last supply is the 12-volt 400 Hz which activates buzzer alarm on the auto-pilot should there be a break in the control lines.

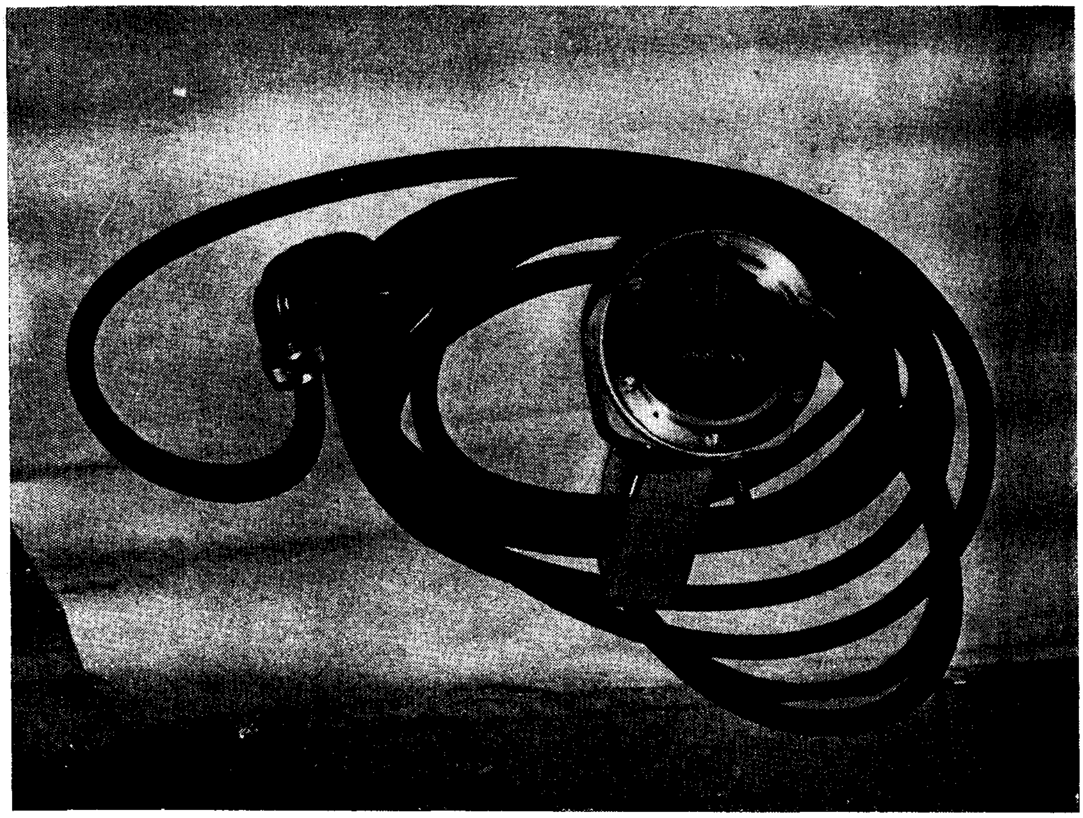

FIG. 4—THE EXTENSION CONTROL FOR USE IN THE BRIDGE WINGS

The five units in the system are: the Auto-Pilot, the After Control and Fuse Panel, the After Power Unit Controller, the After Power Unit and the Inverter.

The Auto-Pilot

FIG. 3 shows the auto-pilot, and FIG. 4 an extension for use on the bridge wings for alterations of course during replenishment at sea.

The operation of the auto-pilot was explained in the July, 1970, issue of the *Naval Electrical Review*. To repeat the basic details however; when the 'hand' button is pressed control is by means of the 'handlebars' shown in the bottom left unit of FIG. 3. Operating like a conventional wheel, rudder angles are put on electrically. The auto-mode is controlled by the top right-hand unit. The outline of a ship, pointing at 343 degrees in FIG. 3 is the dialled course. The bow pointing at 240 degrees in FIG. 3 represents ships head. To transfer to the auto-mode the dialled course is matched to the ship's head and the auto button is pressed. The dialled course is then turned to the required bearing and ships head follows. FIG. 4 shows the RAS unit, used from the bridge wings when the auto-pilot is in the auto-mode. Flicking one of the two switches below the indicator causes the auto-pilot set course dial to be moved in $\frac{1}{2}$ degree steps to port or starboard, depending on which switch is used, and hence an alteration in course is effected. The indicator shows only the units of the course dialled, thus the reading shown in FIG. 4 is — — $2\frac{1}{2}$ degrees. 'Flicking' an alteration in course will therefore be recorded on the auto pilot dial and on the RAS indicator.

The After Control and Fuse Panel

This unit is the emergency after steering control and a hand control lever Linvar is fitted. It would be used in the situation where a break in the control cables has occurred. A key is inserted in a lock, a switch can then be moved

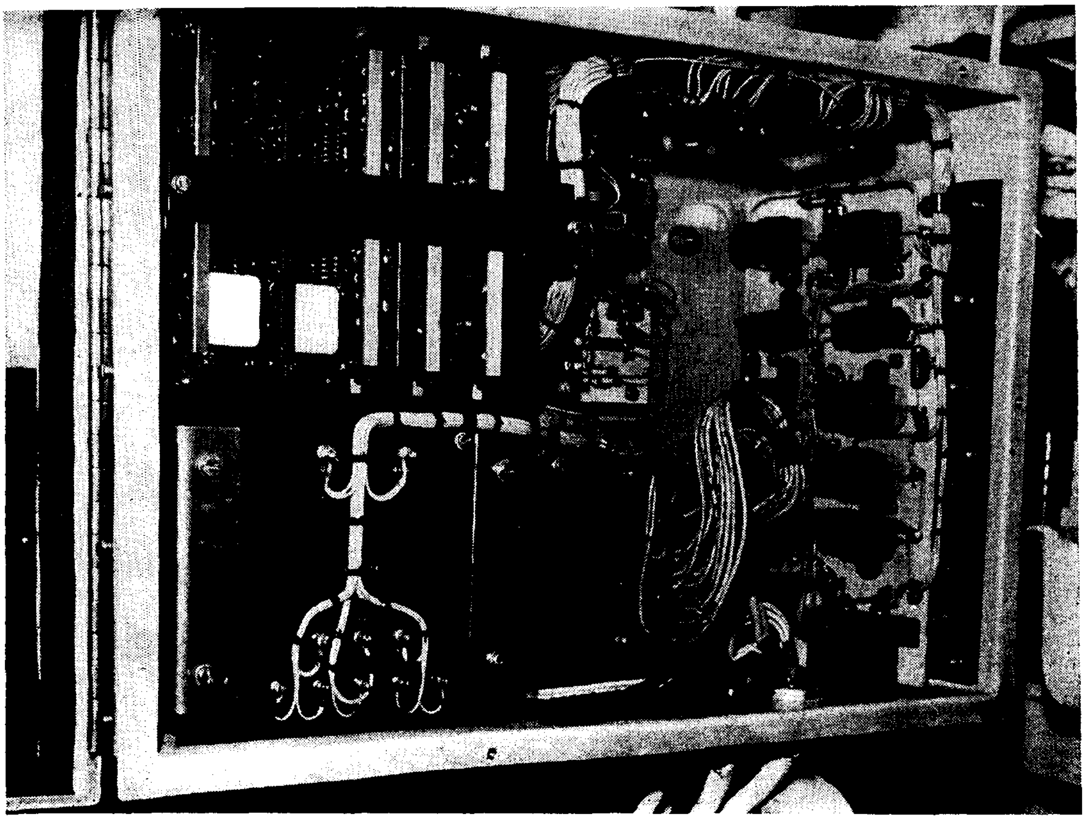

FIG. 5—THE AFTER POWER UNIT CONTROLLER

from 'remote' to 'local', and control is then by means of the hand lever. The normal rudder demands are routed through the unit as are the supplies to and from the inverter.

The After Power Unit Controller

The position servo for the rack is housed in this unit. It is made by A.E.I. and incorporates some of the more advanced engineering techniques. (FIG. 5.)

Positional feedback is routed to this unit from the rudder head, and transient velocity feedback is routed from the rack itself. Fault finding in this unit has not been easy. In particular checking voltage levels and signal paths has been a problem, mainly because the only method available at present is to identify the required signal inputs/outputs from a handbook and then attempt to monitor with an AVO. There is a strong case here for a fitted meter and a selector switch. As FIG. 5 shows, the depths of this unit is rife with cable and identification is difficult.

The After Power Unit

This unit comprises a d.c. motor driving through a magnetic clutch and gearbox onto a rack, shown in FIG. 6.

The rack moves a linkage, the first stage can just be seen. This is the linkage which causes offset on the normal hydraulic steering motor. There are limit stops to prevent excessive rack movement and one can be seen just below 'SW.2' in FIG. 5. There is another stop, in an identical position on the other side of the rack.

The magnetic clutch circuit was modified to cater for 115-volt 400 Hz failure. If the failure does occur the clutch is de-energized, allowing the rudder to be

FIG. 6—THE AFTER POWER UNIT

re-centred under the action of the telemotor system. Were the clutch not de-energized the rudder would not re-centre as the linkages and rack cannot run back through the gearbox. This refinement means that there is no need to match the telemotor system to the rudder if 115 volts fails as there would be were the rudder left on an offset position by the electrical system.

The Inverter

The inverter—the power supply unit—is a good example of the new trend for converted supplies. Supplies are converted on the spot rather than in a central position, so any damage can be rectified by running emergency 440-volt cables. With the present system damage to the conversion machinery can be impossible to rectify.

As described earlier, two supplies are produced, 220 volts d.c. and 115 volts 400 Hz. The 220 volts d.c. is produced via a transformer and silicon diode rectifier bridge. The 115 volts 400 Hz is produced by silicon controlled rectifiers which are controlled by a small transistorized oscillator. The power output of this last supply is 300 VA.

Problems in Chronological Order

The inverter was the first real problem to occur and a number of supply failures were experienced at sea shortly after installation. As a result of these failures the rudder was usually fixed in an offset position. After much investigation it was decided that the power failures were caused by the silicon controlled rectifiers in the inverter being over sensitive to heat. A new inverter was fitted and the problem has not occurred again. To prevent the rudder sticking in an offset position on power failure, the magnetic clutch modification described earlier was fitted.

After the inverter problem was resolved, Cuthbert ran faultlessly for about four months when the next failure occurred. Without any alarm being sounded the rudder remained hard over to port after a turn to port had been dialled. After a certain amount of juggling with 'black balls' and 'short blasts' the steering was reverted to hydraulic control. The fault was eventually traced to the after power unit controller. Difficulty was experienced (*a*) putting the system in an operational state (power on) without actually having control, and (*b*) monitoring the voltage levels as described earlier. It was then found a reversible diode had short circuited, which had caused the armature of the d.c. motor in turn to be short circuited. The object of this rectifier is to protect the motor armature from the high voltage spikes produced in the inverter. The diode was removed and the system ran satisfactorily without this protection. A new rectifier was fitted and six weeks later the same fault occurred again. A

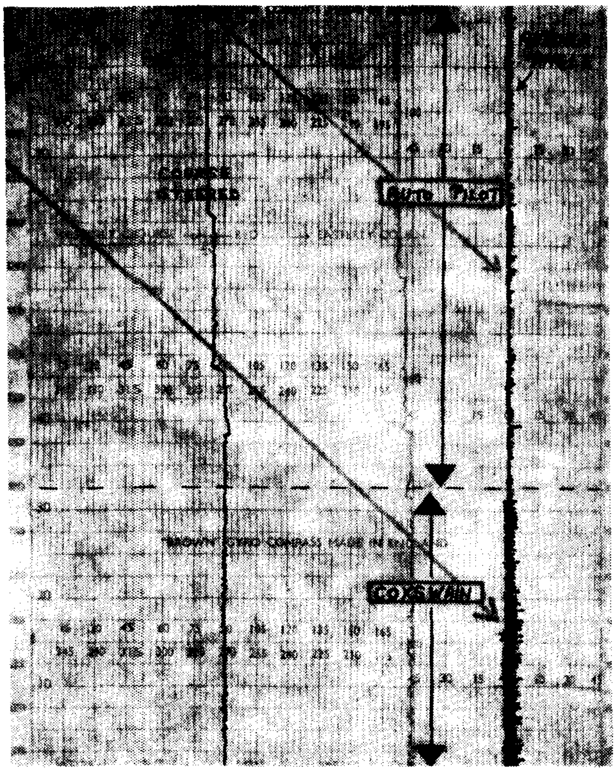

FIG. 7—THE COMPARISON BETWEEN AUTO-PILOT AND COXSWAIN STEERING

third rectifier was fitted and seven weeks later the fault occurred once again. A new diode with a higher voltage capability is now to be fitted, which is expected to rectify the problem.

Two aspects of this failure are worthy of note. Firstly the rudder is locked in an offset position—the magnetic clutch does not de-energize as there is no power failure. Roaring around the ocean at 20 knots with the rudder at 'port 30' is neither good for navigational safety nor for the blood pressure of commanding officers of H.M. ships! No further trouble is envisaged with the diode, which will solve the 'stuck rudder' and 'blood pressure' problems.

The third problem experienced occurred because the steering motor and the auto-pilot supplies were not controlled by the same switch. Thus it was possible to switch off the steering motor and leave the auto-pilot on. This occurred on one occasion with 20 degrees of port rudder applied. The rack moved to starboard in an attempt to take the 20 degrees of rudder off. As the pump was stopped nothing happened so the rack went over to starboard. Eventually the situation finished with the rudder at 20 degrees to port and the rack trying to put on 30 degrees of starboard rudder on the steering motor stroke. This is equivalent to putting on port or starboard 50 degrees! The spring linkages compressed against the steering pump stroke linkage and as a result the floating linkage, which is connected at its centre to the pump stroke, bent by a significant amount. The steering motor and auto-pilot are now controlled by a common switch.

This has been the extent of the troubles experienced to date. Not many surprisingly, but certainly enough to justify Cuthbert's existence as a prototype.

Conclusions

Users and maintainers in H.M.S. *Exmouth* like the auto-pilot/electric-steering system very much. Obviously others do too, as units are already being fitted in new construction ships. There is room for argument perhaps as to the console layout for the new ships; these consoles will incorporate engine orders, gyro tapes, rudder repeats as well as the auto-pilot, but there cannot be any argument about position. It has been found in H.M.S. *Exmouth* to be of immense value for the officer of the watch to be able to dial his own course, especially when station keeping.

He can look at the Radar and adjust course/speed which makes the whole business quicker, quieter, easier and possibly safer, for instead of conning on to the new course he can use the time saved to look around and visually check the situation, before diving once more to the P.P.I. to check his position. For the officer of the watch to be able to do this the console must be at the front of the bridge. Placing the console behind the main part of the bridge would be a mistake and cancel many of the advantages of this new system.

Maintenance aspects must be taken into greater consideration for the future and built-in monitoring for checking the main signal path would drastically reduce the time taken to isolate a fault.

The 'off course' alarm, which buzzes when the ship yaws more than 6 degrees off the dialled course, must be adjustable to cater for the larger yawing angles in rough weather.

The trace in FIG. 7 shows a comparison of the coxswain against Cuthbert steering. The actual courses steered are comparable, but the amounts of rudder used are not. The auto-pilot uses much less wheel which reduces ships drag which leads to an improved fuel consumption.

These then are ships staff conclusions, all of which are known to the relevant authorities and the majority of which are being actioned. The system is liked, useful and has a potential saving in manpower and effort as well as improving fuel consumption. Let's hope Cuthbert's offspring will be as successful as Cuthbert.