NOTES FROM THE SEA

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A TALE FROM THE 7th GROUP DEPLOYMENT

On Monday 30th January 1978, H.M.S. *Cleopatra* was alongside the jetty at Pusan, South Korea. Secured outboard and separated only by fenders was H.M.S. *Amazon* whose machinery spaces had been the centre of attraction in Japan and which were now the subject of much interest from the South Korean Navy. During the previous night, a swell had entered the harbour causing *Amazon* to roll and bump, although not so severely as to give rise to concern.

At 0930 came the announcement of trouble in *Cleopatra*. Main broadcast: 'No smoking aft of the junior rating's dining hall. Fuel flood in the after Seacat magazine'. Daily magazine rounds had revealed the Seacat missiles with only their nose cones poking out of waist-deep neat Dieso.

The after Seacat magazine is sited amidships immediately abaft the engine room and is bounded on the remaining three sides, and below its deck, by the four tanks of the after chain of water-compensated fuel tanks.

The South Korean Navy's liaison officer was asked to arrange for a sullage lighter, while the Chief MEM departed to borrow an air-driven submersible pump from a U.S. Navy warship in harbour. A blanket of AFFF was applied to the surface of the fuel in the magazine as a precautionary measure, and then the fuel in tanks 15 and 16 (which bounded the sides and deck of the magazine) was transferred to the forward chains until the level of fuel in those tanks had been lowered to below the magazine deck level.

In due course, with the arrival of sullage lighter and pump, the magazine was pumped out to leave a soggy, smelly magazine of oozing Seacat missiles, sodden small arms ammunition boxes, and Dieso-soaked bulkhead lagging.

Preliminary inspection did not reveal the source or cause of the flood. The Seacat missiles were removed and ranged on the flight deck for hosing down with fresh water, where perforce they had to stay overnight while work proceeded cleaning up their magazines. Soon after sunset, the temperature fell well below zero and *Cleopatra*'s flight deck became a lethal rink of oily ice.

Down in the magazine, the fuel-soaked lagging was stripped from the bulkheads leaving them bare, except for a rough coating of old adhesive, to a height of 3 to 4 feet. No split was revealed. Dieso was then seen to be oozing out of the lagging midway along the starboard side above flood level. The lagging was cut away up the track of this seepage to reveal a small split in the plating, just the size of a thumbnail. It seemed incredible that something like 15 tons of Dieso could have entered the magazine through such a small split. However, from the slight inward bowing of the bulkhead and the evidence of a small wrinkle in the deck adjacent to the side of the magazine, I was reluctantly forced to the conclusion that the after chain of tanks had suffered overpressure—an impossible event with the correct valve line-up which ensures that the end tank of the chain is open to an expansion system. It seemed that any further split in the magazine plating might have closed up as the tank pressure was relieved into the magazine rendering it undetectable except by crack-detecting fluid. Until, therefore, a better inspection could be made, preferably from inside the tanks, it seemed prudent to keep the fuel level in tanks 15 and 16 below magazine deck level.

At 1000 on the following day, 31st January, with the event still largely unexplained, the ships sailed for Chinhae, a few miles down the coast. The missiles were restowed in the magazine which had been restored to some semblance of habitability. The accompanying tanker, R.F.A. *Grey Rover*, was about to leave us for several days so we refuelled during this short passage, filling the forward chains and topping up the uncompensated fuel tanks. Some 20 tons remained in each of tanks 15 and 16.

Clearly there had to be an investigation. Immediate inspection had shown the water-compensation system valve line-up to be correct and the 'tankies' were adamant that all operations had been properly carried out. Happily, I believed them and in any case, as they pointed out, the after chain had not been used or refuelled for several weeks.

We spent Wednesday, 1st February, alongside at Chinhae. I ordered the handhole door in the expansion tank to be removed. Water was to be poured into the tank from which it would drain through the expansion pipe to the fuel tanks. It didn't. The line and the tankside valve would have to be stripped to discover the cause of the blockage but this could not be attempted at Chinhae. We were due to sail early next morning for Kagoshima and too much work in wake, down between the shafts, was involved for a start on this work to be made at this stage. Furthermore, it would be necessary to empty the end tank in the chain before the tankside valve could be stripped and there was nowhere to put the fuel. Local water-pollution regulations were very strict and I dared not attempt any further transfer to the forward chains since discharged compensating water always carries a trace of Dieso. So we were 'locked out', still with free surface in tanks 15 and 16. I regretted our enthusiastic efforts to top right up on the day before.

Soon after sailing, we received a signal from CINCFLEET with a gentle reminder to read the ship's stability statement. (We had, in fact, done so but it did not seem too much help in the situation we faced.) They disagreed with my earlier estimate of usable fuel remaining, pointing out that we could only use the forward chains; some 180 tons out of a normally very much greater total. I had to advise the Captain that they were right. To use fuel from any other source would worsen an already degraded stability situation. I realized that, while being conscious in general terms that the ship's stability had been adversely affected, I had failed to give the subject proper attention. Would it be better to ballast tanks 15 and 16 up to magazine deck level or empty them as far as possible to minimize free surface? There was nothing for it but to do the sums. Meanwhile CINCFLEET might like to do some too so I sent our tank state.

Matters were not helped by the fact that the ship's Class Book had not been re-issued following Exocet conversion (which included the provision of water-compensated fuel tanks) and so it was little help to me. However, the ship equipment files contained enough graphs of various vintages for an attempt to be made using the delightfully clear and explicit methods given in the NBCD Manual. The weather gave spur to my efforts by gradually increasing to Sea State 4 on the quarter. There was little doubt that the ship felt different albeit the Captain and I spent the evening separately persuading ourselves otherwise. During the forenoon, I had opted for emptying tanks 15 and 16 as far as possible to minimize free surface.

The result of my calculations was that the ship's GM was some 10 per cent. less than that quoted for 'Worst Seagoing Condition' in the stability statement. I had reached this conclusion late in the first watch and at about the same time the officer of the watch used 15 degrees of helm to avoid shipping. The combination of this amount of wheel and the quartering sea resulted in a roll of 25 degrees. Pursuing my calculations, it transpired that the GM would not improve to better than the 'Worst Seagoing Condition' unless tanks 15 and 16 were ballasted to above the magazine deck level; that is, until the free-surface areas of the tanks were reduced by the plan area of the magazine. And I had not allowed for the free surface existing in tanks 17 and 18 resulting from their not being pressed full.

Happily we arrived at Kagoshima at 0900 the next morning with no ill effects more serious than a chastened SMEO. CINCFLEET's reply arrived while we were in harbour giving an estimated 20 per cent. below 'Worst Seagoing Condition' and confirming the other conclusion I had reached. It also reminded me that we could have helped matters by ballasting the after trimming tank. It ended with the opinion that, if we kept everything topped up, the situation should not get too serious in those waters at that time of year. As events transpired, we had no cause to put this opinion to the test.

In Kagoshima, we had our first opportunity to ventilate and enter the tanks. There was no doubt then that the after chain had been pressurized. Three magazine bulkhead frame welds had parted, one of these causing the tear in the side plating. There was no other split. 'Chippy' effected repair using Mazel metal and this proved entirely satisfactory. The magazine remained tight and dry when, in due course, we ballasted the after chain and opened up the header tank to give the chain its normal overpressure of a few inches water gauge.

While the tanks were empty and as soon as we had stopped turning main engines, it was possible to gain access to strip the expansion pipe. The cause of the trouble was quickly found. In the flanged joint of the expansion pipe to the fuel tank was fitted a one-eighth inch Permanite blank, slightly dished due to tank pressure but otherwise quite intact and clearly most effective.

The likelihood is that this blank was fitted during the conversion refit during tank testing three years previously. Failure to remove the blank after testing had all but immobilized the ship, and certainly reduced its fighting effectiveness when a long, long way from home. Naval readers will appreciate our relief at this discovery which exonerated the ship's staff from blame.

Our belief was that a sharp tank overpressure had resulted from *Cleopatra* being squeezed between *Amazon* and the jetty when alongside at Pusan.

Afterword

In the face of some reluctance on the part of the ship, we were instructed by CINCFLEET to effect full repairs in Manilla and we were ultimately most grateful for this instruction. The local contractor was most efficient and did not pause in his work until we had a pristine magazine with the latest specification of deck paint scheme. He was surprised at two things: firstly, that we wanted the Mazel metal removed since it was their standard repair of small tank splits; secondly, that we insisted on empty tanks and a gas-free certificate. They commonly weld against full fuel tanks, requiring only that they be proved completely filled with no gas pockets. I enjoyed being present when the contractor was paid by the Supply Officer, in cash, from a suitcase!

A LATTER-DAY FEED SYSTEM?

Has anyone considered conducting a poll into why Marine Engineers want to serve in COGOG ships? Probably not, but one can't help thinking that it might produce some interesting results. For instance, there may be two categories of aspiring MEOs: those who genuinely want a gas turbine ship for its own sake, and those who want one because the only alternative is another steam ship.

One can imagine some of the typical arguments. In the first place, doesn't the world of gas turbines open up a whole realm of exciting possibilities in the engine health monitoring field, and isn't there the prospect that one day the decision of when to change a gas turbine will be left to a ship's MEO? And on the other hand, doesn't the COGOG MEO finally escape from that twilight world of steam leaks and feed water contamination—that world where the discovery of clouds throughout the feed system heralds days of nightmare watchkeeping if not the end of one's professional career?

Well, perhaps there is something in both arguments—but surely only a small something! With the gas turbine era still in its relative infancy, it may be some time before the Navy discovers the modern equivalent to the leaking condenser tube. Possibly, in that the working fluid has changed, there isn't one. Nevertheless there are bound to be some areas in which the gas turbine MEO might do well to devote a little special attention. These notes suggest one of them—the fuel storage and transfer system. They discuss the system fitted in the Type 21 frigates; perhaps one or two of the points raised have a wider application.

Why Choose the Fuel System?

A not unreasonable question when one considers that Type 21's have now been operating successfully for about six years and that there is nothing special about the fuel system. It is of straightforward design, owing something to aircraft practice; it is simple to understand and simple to manage—given good fuel. But therein lies the first snag. For how does one manage a simple fuel system when it is not supplied with good fuel?

The second spur for these notes is a consideration of today's fuel supply situation. The aero-derived gas turbine demands clean, unadulterated dieso; with its simple fuel system, the Type 21 appears rather vulnerable to the opposite. Yet the supply of high quality dieso does not seem so assured. The commercial maritime world is depending increasingly on residual fuels and there is an abundance of ships in the Fleet which do not need water-free dieso. How many MEOs have been offered contaminated dieso from a variety of sources? One was recently confronted with a Middle Eastern shore storage tank in which the clean dieso lay on top of 15 feet of stagnant water!

The third reason for these notes, and perhaps the most cogent, is an appreciation of the excessive waste of ship's staff effort and loss of operational flexibility that can result from water contamination of a Type 21's fuel system.

The System

Fuel is stored in fifteen unballasted storage tanks distributed along the ship's bottom in forward and after groups. From there it is transferred, via the common filling/transfer main, to the four service tanks sited in the forward auxiliary machinery room (FAMR). Normally, the transfer pump in the forward fuel module is used to transfer fuel from the forward group of storage tanks to one pair of service tanks; likewise the after pump takes fuel from the after storage tanks and transfers it to the other two service tanks.

Fuel is then drawn from the service tanks by one of two boost pumps, sited again in the forward and after fuel modules (FIG. 1). It is delivered to the boost ringmain through pre-filters (to remove solid matter) and Fram coalescers (to remove water). The boost ringmain acts as a pressurized reservoir from which the running gas turbines draw their fuel. Cross-connections and spectacle plates are fitted to the boost and transfer systems, but these were intended for emergency use only. Essentially the transfer of fuel from storage tanks to gas turbines is a very simple business, as FIG. 1 implies.

The position of the fuel filters in an open loop between the service tanks and the gas turbines indicates why the fuel system is sensitive to contamination. Clearly, because of the risk of damage to engine fuel system components and hot parts and of contamination of the fuel servo system, no water must be allowed to reach the gas turbine. Thus, if water is picked up from the service tank by the boost pump, the Fram filter must prevent all of it from being passed to the engine. For a number of sound operational reasons, this is a tall order; far better to keep the water well away.

Service Tank Arrangements

Besides the filling and overflow pipes and the high- and low-level alarm components, each service tank is fitted with a suction pipe, a sampling tube, and a drain pipe. The suction pipe is inverted and allows fuel to be sucked out down to a level of about 35 cm from the tank bottom. The sampling pipe, about 4 cm in diameter, lies about 5 cm from the (flat) tank bottom. The 8-cm diameter drain leads (from 10 cm off the bottom) to number 7 or 8 storage tank. Thus, if a service tank does become contaminated by water, it can be cleared by draining the water down, but only to a certain level. To remove all contamination it is necessary to open up the service tank and to mop out; this is the second good reason for not allowing water in the service tanks.

Then, if water has been drained from a contaminated service tank, what should be done with it? For if one does give in to the natural impulse to remove it from number 7 or 8 tank by transfer pump, almost certainly the filling/transfer system will become recontaminated; also, the tank to which the water has been transferred then becomes unusable, as the next section will reveal. The only possible reason in favour of transferring from number 7 or 8 tank is that they both lie beneath the two forward diesel generators and the two auxiliary boilers This makes cleaning them a thoroughly tiresome business.

In other words, once water is allowed into a service tank, there is a strong risk of the contamination being spread, of considerably restricting the operational flexibility of the fuel system as a whole, and of greatly increasing the subsequent tank cleaning work. The conclusion is obvious.

Storage tank arrangements

Each storage tank is fitted with a supply pipe, a suction pipe, a sounding tube, an air escape, and the components of the tank contents indication system. Each suction pipe terminates in an elephant's foot in the deepest part of the tank; this is so arranged that the contents of the tank bottom are the first to be removed on transfer. Thus, if water is present, it will be the first to be transferred—to the service tanks.

There is no fitted stripping system. Stripping can be achieved through the normal suction pipe, or by portable hose through the tank lid, or, conceivably, through the sounding tube.

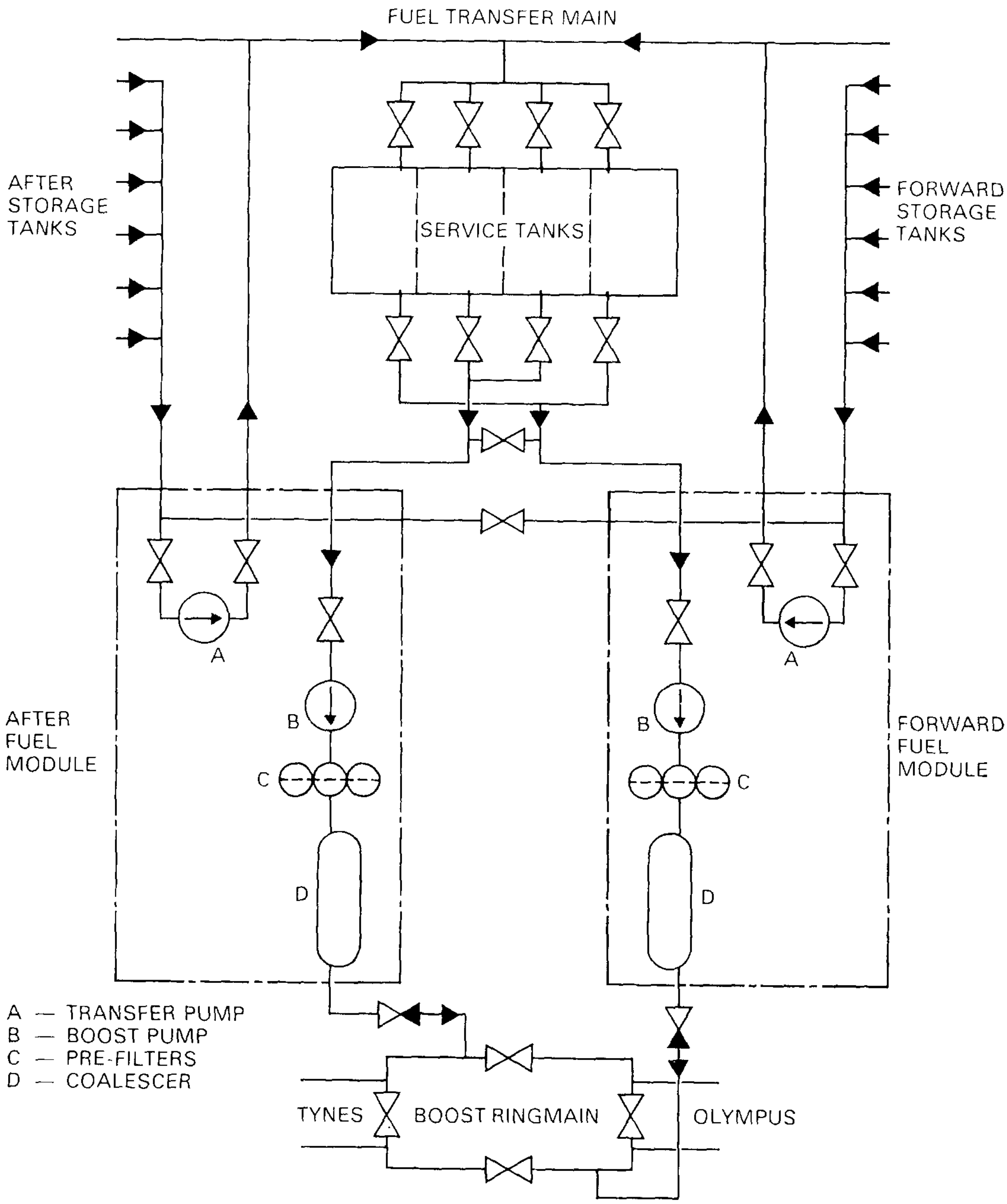

FIG. 1—SCHEMATIC ARRANGEMENT OF FUEL TRANSFER AND BOOST SYSTEM

Dealing with Contamination

Possibly one or two aspiring MEOs will now have reached for their pens to suggest how, with the aid of modern distribution theory, a contaminated Type 21 fuel system can be worked and cleaned without disruption to the rest of the ship. Hopefully they will not be deterred by MEOs who know from experience that the only answer is not to embark any water at all. But until a new operating technique or a modification is introduced, this must be the only safe advice—Fram coalescer and all.

It has so far been assumed that water contamination is the type to be treated the most seriously. This is no accident. Solid contaminants should normally present little problem since settlement under gravity will prevent appreciable quantities from reaching the service tanks. The main enemy must be water, not only because of its effect on the gas turbines, but also because it has to be present for microbiological organisms to thrive.

Much has been written elsewhere about the growth and its effect upon filters and fuel system components. Suffice to say that its presence, even in small quantities, can have a most remarkable effect on those who come into contact with it—there appears to be a marked psychological reaction to the presence of unfamiliar organisms.

Detection of water in dieso is a simple matter. Despite the availability of detector capsules and modern innovations such as the electronic 'bleeper', visual examination remains a most effective and reliable method. A succession of old mustard jars at the fuelling point and a sharp eye will ensure that no water is embarked; the Shell detector capsule provides confirmatory evidence. In a Type 21, the only standard of acceptability appears to be a sample of fuel which is bright, sparkling and clear to the naked eye. Clouds are unwelcome.

Conceivably, operational circumstances may leave the unfortunate MEO with no choice but to take on some water with his dieso. With luck he will have taken advance measures to limit the extent of contamination. Preferably, fuel will only be embarked into numbers 7 and 8 tanks, perhaps into only one of these. But what to do then?

The golden rule seems to be to leave the contamination there and not to risk spreading it about the rest of the system. The next thing seems to be to flush through the filling/transfer pipework with clean fuel, discharging it into the contaminated tanks. Then at least the remainder of the system can be operated in the normal way and the chances of affecting the ship's operational readiness are minimized. If this sounds melodramatic, it is worth noting that by not taking these simple precautions it can literally take days to reach a stable position from which a clear picture of the extent of contamination emerges; water has a habit of turning up in the most unexpected and unwelcome places in fuel systems.

If proper sullage facilities are to hand, this should be the end of the matter. However, they may not be, particularly if the ship is at sea for a prolonged period; in any case, the loss of good fuel may be considered economically unacceptable. Under these circumstances, the MEO is left with self-help using the limited resources at his disposal. In the Type 21 self-help comes in two forms:

(*a*) Stripping and sullage.

(*b*) Self-purification of stored fuel.

Stripping and Sullage

Because of the risk of again contaminating the transfer system, the use of the suction pipes for tank stripping is discounted, unless the purpose is to transfer appreciable quantities of dieso-water mixture to a more convenient place. If the purpose is to remove only free water lying on the bottom of a tank, then portable pipes seem the only answer. As suggested earlier, one possibility would be to

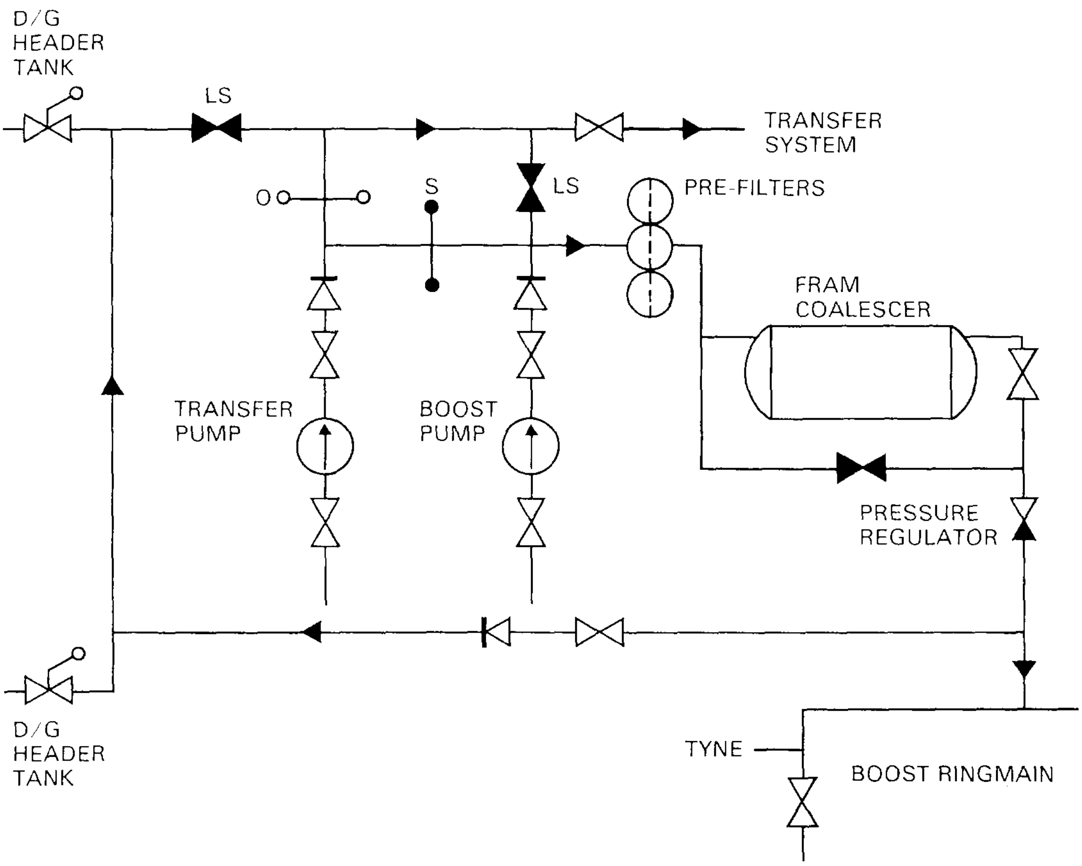

FIG. 2—SCHEMATIC ARRANGEMENT OF EXISTING FUEL TRANSFER AND BOOST PUMP DISCHARGE PIPEWORK

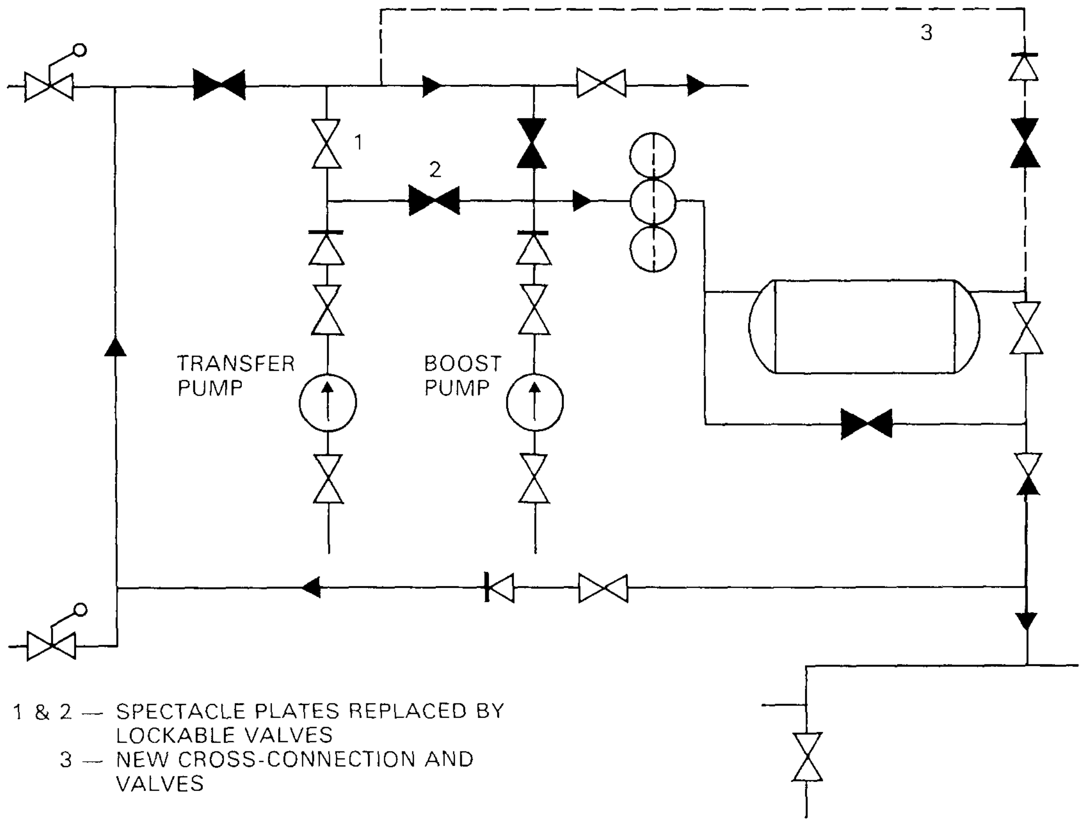

FIG. 3—SCHEMATIC ARRANGEMENT OF PUMP DISCHARGE PIPEWORK MODIFICATIONS (cf. FIG. 2)

use the sounding tube as a means of removing water from the tank bottom. At present, this would be only partially successful in that the sounding tube ends about 10 cm from the tank bottom, and it would be necessary to pass a small-bore semi-rigid suction pipe down the sounding tube.

Where appreciable quantities of dieso-water mixtures are concerned, the Type 21's designated sullage facilities are inadequate. Then, number 15 storage tank can be very convenient for use as a temporary sullage tank. It is relatively small, it has ready access for eventual cleaning, and it is at one end of the filling/transfer system. By using it in preference to any other storage tank, the risk of interrupting the ship's operational availability is kept to the minimum.

Self-purification

By a piece of good fortune, existing pipework and cross-connection arrangements in the Type 21 allow the fuel modules to be used to purify fuel without passing it into the boost system. Normally the boost pump takes fuel from the service tanks and passes it to the ringmain through the filters and the pressure regulator. Between the regulator and the ringmain a small-bore pipe branches off, supplying fuel through a pair of valves to the diesel generator header tanks. This line also links up with the transfer system (FIG. 2).

By changing over the spectacle plates on the discharge side of the pumps, and by isolating the adjacent corner of the boost ringmain it is possible to use this 'topping-up' line to return fuel to the storage system after passing it through the fuel filters and coalescer. Use of a fuel module in this way has shown that up to 8 tons per hour of contaminated fuel can be cleaned whilst the ship is otherwise operated normally. The drawbacks are that there is no standby fuel module during the process, and that the adjacent gas turbine is not fully available. The rate of purification is limited by the small bore of the 'topping-up' pipe. Provided the fuel is otherwise clean, there appears to be no lasting harmful effect on the Fram coalescer, which is specified to be capable of removing up to 5 per cent. of water continuously.

A Simple Modification

A simple and inexpensive modification could help improve considerably the tolerance of the Type 21 fuel system to water contamination—should it be allowed to occur. This would consist of replacing the spectacle plates on the discharge side of the transfer and boost pumps with lockable valves, and of adding a cross-connection line and isolating valve to join the transfer main to the discharge side of the Fram coalescer (FIG. 3). It would then be very simple to convert the fuel module into a purifying station for the stored fuel without disrupting the adjacent gas turbine, and to make full use of the capacity of the transfer pump.

So What's New?

Hopefully, no one will regard the foregoing as a vehicle for pointing accusingly at the design of the Type 21 frigate. Whatever the detail design inconveniences, the really telling point is that those who serve in the 21's appear genuinely enthusiastic about their ships. They appreciate serving in stylish and purposeful-looking ships in which the many varied needs of ease of fighting and comfort of living have been closely harmonized.

Rather, these notes will have served their purpose if they have helped to show that operation of modern ships is not simply a matter of using digital voltmeters, pocket calculators, and laboratory tests. Avoidance of contamination of the fuel system also plays a vital role.

Ship Department Comment

This modification to the fuel system of the Type 21 frigates is now under consideration in the Ship Department.