# CHEMICAL CLEANING OF BOILERS AND FEED SYSTEMS

*The following article is an edited version of a report on the Chemical Cleaning of Boilers and Feed Systems carried out in H.M.S.* Berwick. *The report was originated by Lieutenant I. Brannan, B.A., Grad.I.Mech.E., who was loaned to H.M.S.* Berwick *while the work was in progress.*

**Introduction**

During a recent guinea-pig period for a Type 12 frigate it was necessary to carry out chemical cleaning of main boilers, internally and externally, together with chemical cleaning of the ship's feed systems. Internal cleaning of boilers and associated feed systems became necessary as a result of contamination of the system with OEP-69 lubricating oil. External cleaning of the boilers arose as a result of a detailed inspection. The extent and disposition of fireside deposits in the superheater and generator tube banks and on the water drums was such that removal was considered necessary in order to reduce the risk of further superheater tube failures.

As the internal and external cleaning had by necessity to be progressed concurrently, the minimum amount of interference between the processes was essential.

The work was planned in four distinct phases, as follows:

(*a*) External cleaning of boilers

(*b*) Cleaning of engine-room feed systems (concurrent with (*a*) )

(*c*) Cleaning of boiler-room feed systems and economizers

(*d*) Internal cleaning of boilers.

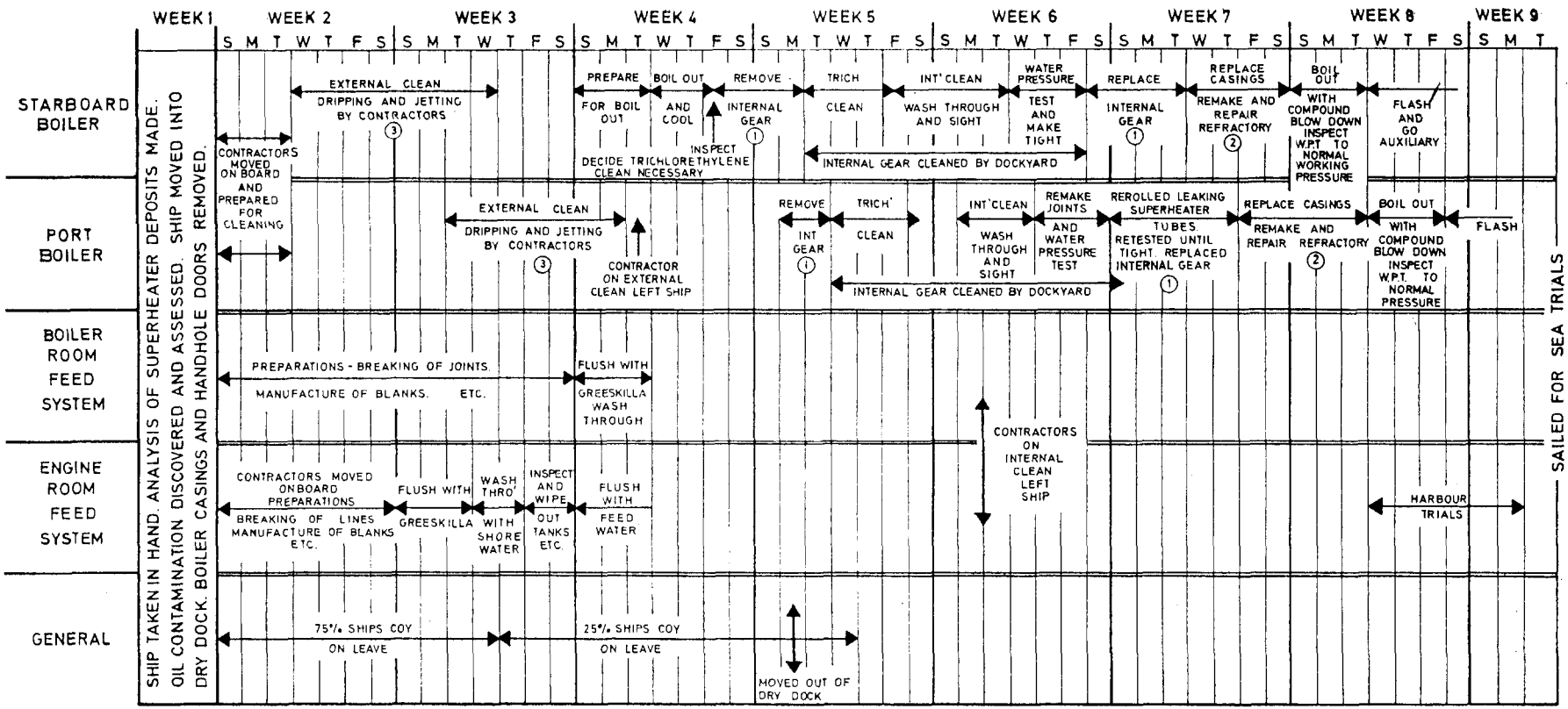
An approximate time-table of the work carried out is shown in FIG. 1.

## EXTERNAL CLEANING OF BOILERS

The chemical process had previously been used in several ships, including Typ 12 frigates, with varying degrees of success but it had always been carried out at the same time as a Wear and Waste Test when tube renewal was necessary. As our time was limited, it was decided to attempt chemical cleaning without removal of any boiler tubes for access.

performance at sea should be concentrated in this direction. Perhaps the R.N. aircraft repair organization could improve the aircraft spares position by being allowed to adopt some of the U.S.N. methods. This may be impossible for many reasons, some of them geographical and historical and outside their control. The final conclusion remains the same, however, that poor spares support is not unavoidable, and it is hoped that this article helps to prove this point.

*Note:* Since this article was written, Overhaul and Repair departments have become separate commands. They are now tenants on an air station rather than an air station department. Since 1st April, 1967, they have been known as Naval Aircraft Rework Facilities.




NOTES. (1) INTERNAL GEAR REMOVED AND REPLACED BY SHIPS STAFF + FMU WORKING TWO x EIGHT HOUR SHIFTS PER DAY.

(2) REMOVAL AND REPLACEMENT OF CASINGS AND BREAKING OF MAJOR JOINTS ON BOILERS AND REPAIR OF REFRACTORY CARRIED OUT BY DOCKYARDS WORKING OVERTIME AND NIGHTSHIFTS AS NECESSARY.

(3) CONTRACTORS WORKED OVERTIME AND AT WEEKENDS AS NECESSARY AND SUPPLEMENTED LABOUR FORCE AS REQUIRED.

FIG. 1—TYPE 12—BOILER AND FEED SYSTEM CLEANING—APPROXIMATE TIME-TABLE

Before the work was started, the Central Dockyard Laboratory analysed deposits removed from the superheater. Although the composition varied slightly according to position, the general composition was found to be sodium sulphate, iron (12 per cent), vanadium compound (equivalent 35 per cent vanadium pentoxide) and other silicaceous materials.

Three solutions were used on the samples to assess the relative softening effect. These solutions were:

(*i*) A 30 volume solution HTP

(*ii*) A 30 volume solution HTP with 1 per cent volume Teepol

(*iii*) 1 per cent aqueous solution Teepol.

The degrees of softening differed in all cases, depending on the density of the scale. The degree of penetration of solution (*b*) tended to be slightly better than the other two. Solution (*c*) when used at room temperature was the least effective. It was obvious, however, that in all cases the softening effect of the chemical would have to be accompanied by mechanical methods, e.g., hydraulic jetting, sawing, etc., for removal of the deposits.

At the same time, the effect of the various chemicals on the boiler refractory, chrome ore, was investigated. No chemical effect was noted but during the subsequent cleaning process furnace floors and chrome ore were damaged mechanically by the high-pressure water jets. Softening of the boiler insulation also occurred after the bitumastic sealing applied over the furnace floors had lifted during the water jetting.

A 30 volume HTP and Teepol was used during the cleaning process. The solution was led by gravity from a header tank on the upper deck to 'drip' tubes (copper tubes with 1/32 in. holes drilled along their length) placed inside the boiler.

The process consisted of a 48-hour continuous drip followed by water jetting at 600 lb/sq in. This was followed by examination and, where considered necessary, the whole process repeated.

In order to give good access to the generator tubes and superheaters, boiler casings, superheater side closing and apex plates were removed. (As stated earlier, the usual precautions were taken to protect the furnace refractory by sealing with bitumastic over newspaper.) The drip tubes were then laid along the top of the superheater tubes.

The coverage of the superheaters by this simple means was reasonably satisfactory although the rake of the superheater tube nest made complete coverage very difficult. The drip tubes were also inserted through the access afforded by removal of 'B' soot-blower which normally scours the generator tubes immediately adjacent to the superheater. In this position, however, the amount of removal achieved was limited. The possibility of using this access more effectively requires further investigation.

A continuous re-circulation method was also used in an attempt to improve the removal of deposits in the generator tubes and on the water drums. This consisted of a small pump taking suction from the furnace floor via the furnace drain and spraying onto the generator tubes through the drip tubes.

The method in general was successful in cleaning the superheater of scale and deposits. Difficulty of access to the generator tubes, aggravated by the need to avoid tube withdrawals, gave only limited success in the areas of the generator tubes.

**Summary**

This is the first occasion on which this method of chemical cleaning has been attempted in a Y.100 design of boiler without tube removals. Because of this the degree of success in removal of deposits in the generator tube nests was limited. It is considered, however, that there is considerable scope for further

development in this process and that had more time been available the degree of success would have been considerably improved.

Although in this case the work was undertaken by contractors, it is considered to be well within the capacity of ships staff.

The time required to carry out the task will naturally depend on the extent, composition and distribution of deposits but in the average case it is considered that a period of 5 to 7 days should be adequate for the cleaning of one boiler, excluding time for removal and replacement of casings, and consequent repairs to furnace refractory, etc.

## ENGINE-ROOM FEED SYSTEM

The process consisted of flushing through the feed system with a hot (140 degrees F) solution of a degreasant. In this case a trade product 'Greeskilla', supplied in powder form, was used in the proportion of $\frac{1}{2}$ cwt to 1 ton of water. In some heat exchangers where the fluid circulation velocity obtainable was not sufficiently high, vapour cleaning using trichlorethylene was necessary. No special equipment was required, pumps already in the system being used to circulate the cleaning fluid round the systems. Special hose connections and adaptors were made from local resources.

FIG. 2 shows in diagrammatic form the basic engine-room feed system together with the primary and secondary flow circulation paths used, as described below.

### Procedure

(*a*) The harbour service pump was used taking suction from the suction side of the starboard extraction pump, discharging through an armoured hose to the extraction pump discharge cross-connection line. (Connection piece required.)

(*b*) The return from the system was taken through a temporary connection in the main feed pump discharge line to the main feed tank, the supplementary valve from the latter to the port condenser via the closed feed controller being left open.

(*c*) A hose was led from the LP saturated steam line to the main feed tank to heat the de-greasing fluid. The whole system was heated up and circulated with fresh water for 12 hours before adding the Greeskilla, previously mixed with water in buckets, into the system through the turbine/condenser inspection doors and circulating it for 24 hours.

*Note:* It is important that Greeskilla should not be added to a system in powdered form but must be mixed into a concentrated solution first.

(*d*) To clean the turbo generator condensate lines to the main feed tank, the non-return valves on the main feed tank were removed and the line broken to facilitate back-flushing.

(*e*) Deaerator float controls were gagged and the deaerator filled and emptied several times.

(*f*) The auxiliary boiler feed pump suction was flushed through.

(*g*) The Sulzer feed pump stand-by suction line was flushed through.

(*h*) Main condenser tubes were hosed down with hose discharge from the main feed pump discharge line.

(*j*) The overflow tank was cleaned by draining it into the main feed tank.

*Note:* To ensure all pockets were cleaned it was found necessary to:

(*i*) Change over feed controllers

(*ii*) Remove the lower gauge-glass cocks from each controller in turn

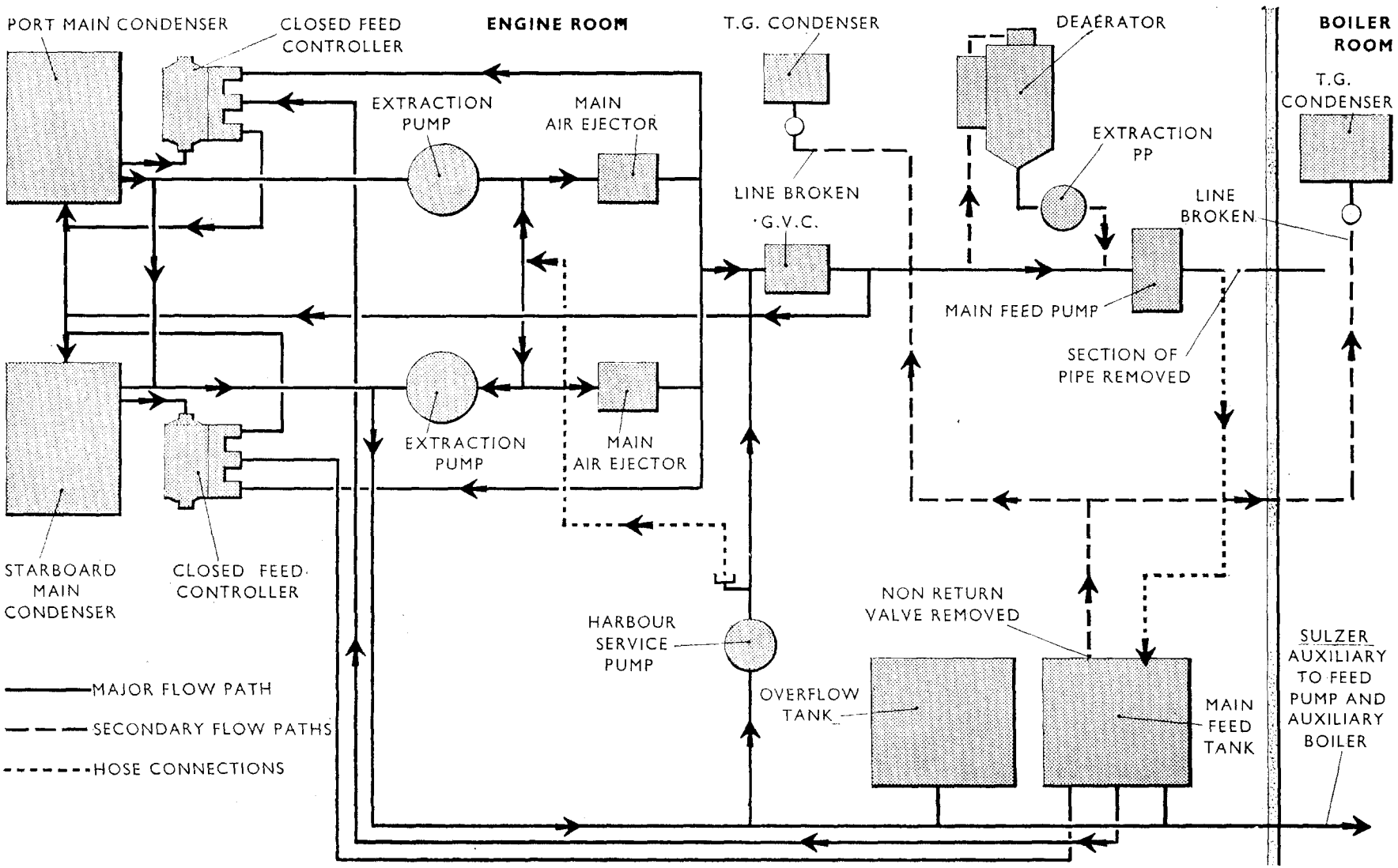



FIG. 2—FLUSHING OF ENGINE ROOM FEED SYSTEM

(*iii*) Remove a plug from the bottom of the port extraction pump casing to close a 'dead' length of pipe between the condenser and the extraction pump discharge cross-connection.

(*k*) The system was emptied into the bottom of the dry dock through the the condenser discharge (through the inspection door). The system was then further flushed through with fresh water until the pH value fell to 6. This process was aided considerably by the fact that the ship's firemain at the time was supplied from the shore fresh-water firemain.

(*l*) Final inspection of the system was carried out. Presence of 'white bloom' of micro thickness and 'soapy' to the touch was observed (BR 3001, Art. 1220(7) refers) on surfaces in feed tanks and the deaerator. These deposits wherever possible were wiped off. Slight traces of grease remaining in the float chambers of the closed feed controllers and the deaerator were removed by wiping out with trichlorethylene.

This process emphasized the fact that for the degreasant fluid to be effective a good scouring action is essential. It is therefore of little use for degreasing heat exchangers of large volume.

The method used to de-grease the turbo generator condenser in the engine room using trichlorethylene is described below under 'Boiler Feed System'.

## BOILER FEED SYSTEM

The cleaning of the boiler feed system was carried out on completion of external cleaning with the ship still in dry dock.

### Procedure

(*a*) The reciprocating auxiliary feed pump was used to circulate degreasant fluid from a reserve feed tank previously degreased, through the main and auxiliary feed check valves and feed system, and through the economizers.

(*b*) The feed water discharge from the economizers to the steam drum was broken and blanked, the economizer draining back to the reserve feed tank through the economizer drain hose connection. FIG. 3 shows a diagrammatic sketch of the system.

*Note:* On completion of cleaning of the system a slight bloom was noticed in the economizer tubes but this was easily removed by flushing through with fresh water. In other respects, the procedure for cleaning the system was similar to that already described for the engine-room feed system.

## INTERNAL CLEANING OF BOILERS

Deposits in the boiler were first noticed during a routine internal inspection. Fine reddish deposits above the normal water line in the steam drum when touched revealed thick carbonaceous deposits. A bullet brush when passed through the tubes came out heavily coated with similar deposits. In the water drums there were several large lumps of thick grease.

Initially it was hoped, with limited time available, to degrease the boiler by boiling out with Greeskilla.

### Procedure

External cleaning was in progress on the boilers and the removal of the registers for modification prevented boiling out by firing the boilers. With the steam off-take pipe blanked and the economizer isolated, the starboard boiler was filled and boiled out with heating steam being supplied through hose connections on the running-down valves and the pre-mixed and pre-heated

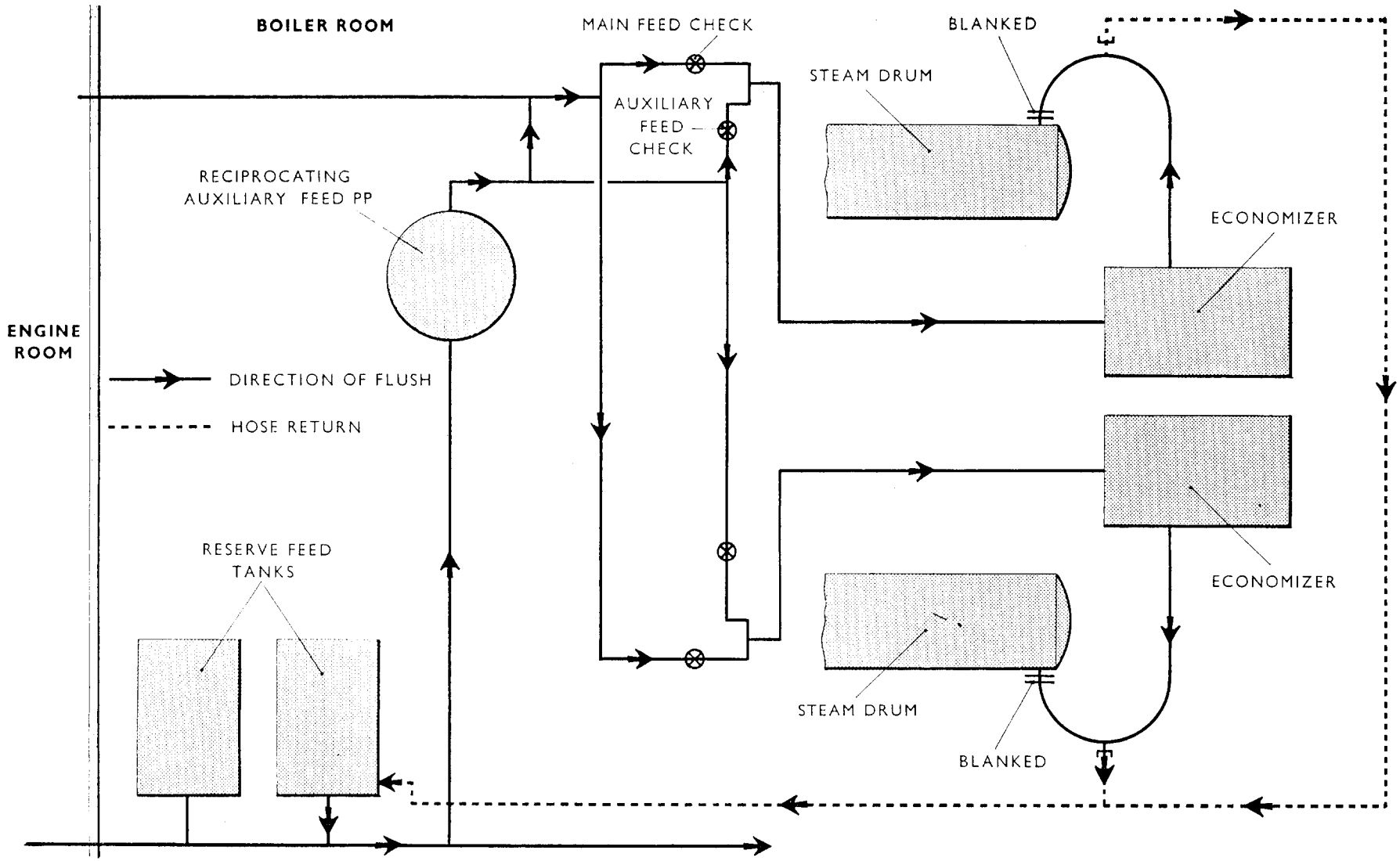



FIG. 3—FLUSHING OF BOILER ROOM SYSTEM

degreasant fluid in the reserve feed tank having already been pumped into the boiler through the running-down valves. The boiling out process was continued for 24 hours.

On completion, however, examination revealed that the stickiest deposits in the steam drum remained and globules of grease still remained in the water drums. It was therefore reluctantly decided that cleaning using trichlorethylene would have to be undertaken, and the procedure for this was as follows:

(*a*) All internal gear was removed from the boiler by ships staff and the Fleet Maintenance Unit for chemical cleaning in the Dockyard.

(*b*) Inlet to the internal feed pipe and off-take to the superheater were blanked.

(*c*) The common blow-down line from the water drum and the water wall headers was broken. Thirty-five gallons of trichlorethylene liquid was introduced through the line into the water drum and lower water wall headers.

(*d*) A steam hose was connected to the blow-down line and steam admitted to the boiler under control of individual blow-down cocks.

(*e*) Trichlorethylene vapour in the form of a dense white gas (6 to 7 times heavier than air), generated as a result of steam heating, rose through the cooler tubes, dissolving the grease, condensing on the cooler surfaces and then falling back into the water drum and headers. The vapour quantity built up gradually until it was emitted from the steam drum air cock. At this stage, steam was shut off, the system allowed to cool and the contaminated trichlorethylene liquid allowed to drain back through the running-down valves. It was then drained off the system and collected for re-purification for further use.

(*f*) The boiler was then opened and the remaining traces of trichorethylene wiped out.

(*g*) Components of the Copes feed regulators were flushed through with trichlorethylene liquid.

(*h*) On completion of the chemical cleaning, all tubes were cleaned by the bullet brush method. Internal gear was replaced and the boiler washed through.

*Note:* Trichlorethylene is not inflammable but if brought into contact with a naked flame emits phosgene, an extremely poisonous gas. Strict 'no smoking' regulations are therefore essential in the boiler rooms and other work at lower levels should not be permitted. The additional anaesthetic effects of the vapour also require that any wiping out in the confined spaces of water/steam drums must be done wearing breathing apparatus. All trichlorethylene should be recovered after use.

Thorough washing through is essential after this process; BR 3000, Art. 1220(6) refers. In the light of the warning contained in BR 3001, Art. 1221, a careful examination of the boiler was carried out on completion of cleaning and water-pressure testing. Only a slight trace of oil contamination was found across the top of the port boiler steam drum and this was easily removed with a rag soaked in trichlorethylene.

## CLEANING OF TURBO GENERATOR CONDENSERS

The cleaning of the turbo generator condensers was achieved by a similar method to that described above for the boilers. Trichlorethylene liquid was poured into the condensers and steam heating applied. The turbo generator ejector condensers were cleaned by washing through with trichlorethylene liquid.

## SUMMARY

The work was carried out by ships staff with the assistance of the Fleet Maintenance Unit, Dockyard and Civilian Contractors. To complete the programme shown in FIG. 1, considerable overtime was necessary.

Although the liquid and vapour processes are basically straightforward the assistance of civilian contractors was invaluable, mainly because of their background knowledge of previous similar cases and their knowledge of the capabilities of the chemicals used and their optimum use.

It is essential when preparing to start work on cleaning feed systems to study carefully beforehand in detail the ship's feed system in order to ensure no 'dead' pockets are forgotten.

In cases of less heavy contamination it is very likely that internal boiler cleaning can be accomplished satisfactorily by a boiling out process alone, but where the degree of contamination is heavier, the steaming action of the boiling out process is insufficient and the trichlorethylene vapour process becomes necessary.