SEWAGE TREATMENT IN H.M. SHIPS

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The Facts of Life

For most of us, except for submariners, sewage disposal has been a lifelong practice of pull the chain or push the knob with the confidence that no further problems will worry us. Either the all-embracing sea or some mysterious organization will cope. Not for long will this careless situation prevail, for pollution prevention regulations are springing up around us. Before long every seagoing engineer will be liberated from past inhibitions and will know that it is not all dealt with by fairies. They will also find that the methods used for sewage treatment give the subject a rather fascinating quality.

There are two basic ways of dealing with sewage aboard ship. The first is to process it biochemically until it is pure enough to discharge overboard in regulation-controlled areas. The second is to store it, in some cases partially treated, until one can discharge it overboard to a shore sewage system where pollution control is not required. It is the biochemical method that has been chosen for future H.M. ships because of the flexibility it gives to the ship to operate anywhere in the world whatever existing or future legislation demands. This article will therefore describe the 'extended aeration' system.

Raw sewage contains both aerobic and anaerobic micro-organisms, as well as bacteria which inhabit our internals, of which by far the most prevalent is *bacteria coli*. An aerobic bug is one which thrives only in the presence of oxygen so long as it also has enough to eat, whereas the anaerobic type requires no oxygen. If sufficient oxygen is present the aerobic bugs will consume the anaerobic ones as well as organic matter that is present. CO_2 is produced in the process and the resulting effluent, after destruction of the bacteria by chlorination, is sterile and pure. If however insufficient oxygen is present, the anaerobic bugs consume the aerobics and the result is a putrefying sludge which gives off hydrogen sulphide and other foul gases. These are the processes which occur in all natural waters. If pollution is mild, the organic matter is broken down into simple, harmless substances and the consequent depletion of oxygen is rapidly replaced by diffusion from the atmosphere. If the pollution is extreme then all the dissolved oxygen is used, putrefaction sets in, and the higher forms of life are killed. The measure of any pollution problem is therefore defined by the Biochemical Oxygen Demand (BOD) which is the amount of oxygen in parts per million (ppm) by weight required by the aerobic organisms to purify and stabilize the putrescible matter. A high level therefore indicates pollution and the BOD value of crude sewage is of the order of 200-400 ppm.

A second parameter used to define the degree of pollution is the quantity of suspended solids made up of non-soluble pollutant matter or inorganic solids. The suspended solid count of crude sewage is of the order of 400-600 ppm.

The third parameter is the Coliform Count which gives a measure of the coli bacteria that are present.

The levels of pollution that are recommended and which are being gradually introduced by legislation vary throughout the world, although efforts are being made to standardize. A selection of these are given in TABLE I.

TABLE I—*Permitted Levels of Pollution*

	World Health Organization Recommendation for Sewage Discharge	*UK Royal Commission Recommendations for Rivers and Lakes but not Esturial Waters*	*Ship Department Specifications for Marine Sanitation*	*US Environmental Protection Agency for Marine Sanitation*
BOD ppm	50	20	50	100
Suspended Solids ppm	150	30	80	150
Coliform Count per 100 ml	1000	—	240	240

Thus if our R.N. plants achieve the specified figures, which they will when correctly operated, we can meet any likely pollution legislation that has been or may be introduced.

The extended aeration process is used by several manufacturers of marine sewage plants and their designs differ only in detail. Some circulate the sewage under treatment by pumps, others use air lifts. The degree of initial maceration (breaking up) may vary and the method of chlorination may differ. This article will however describe the G.D. Peters Mark II Marine Units which are being fitted in the Type 42 destroyers. These plants are similar to the earlier ones fitted in the Survey Ships and the Type 82 GMD, but are developed to a simplified specification as a result of trials and sea experience.

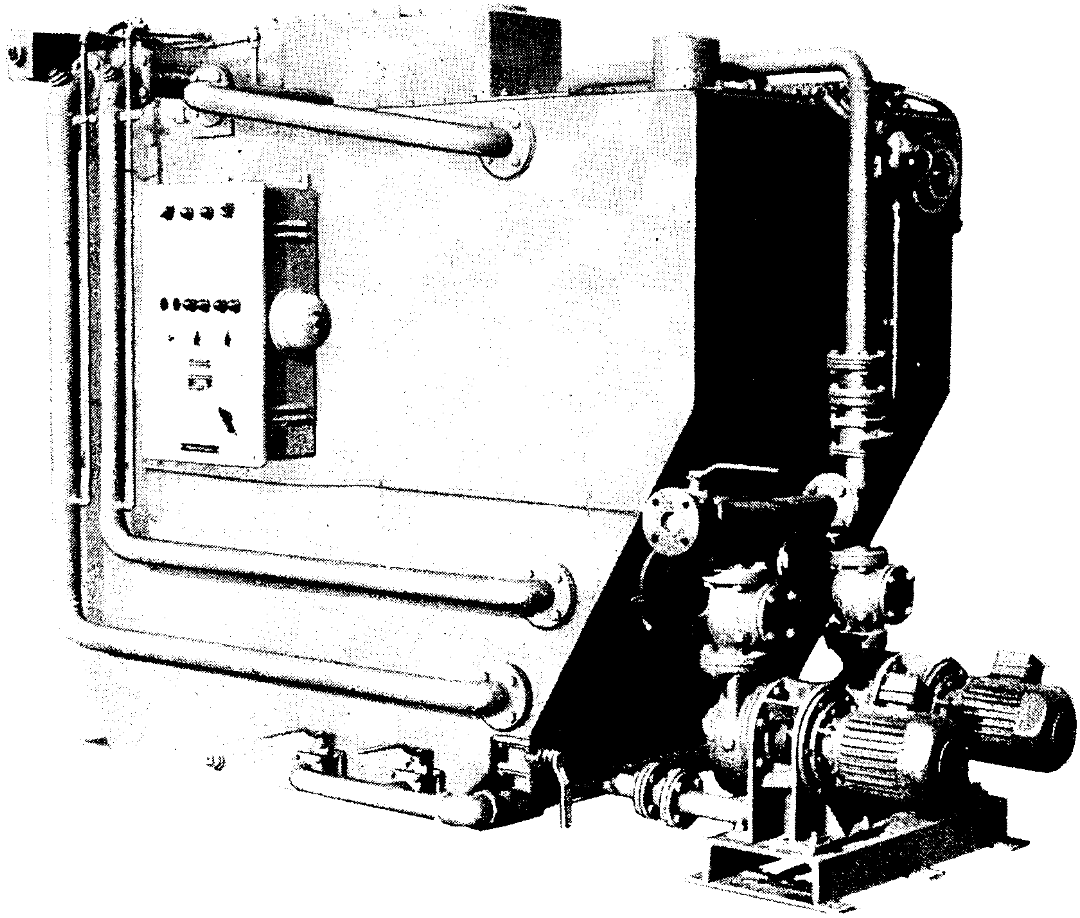

FIG. 1—PETERS MK II MARINE UNIT

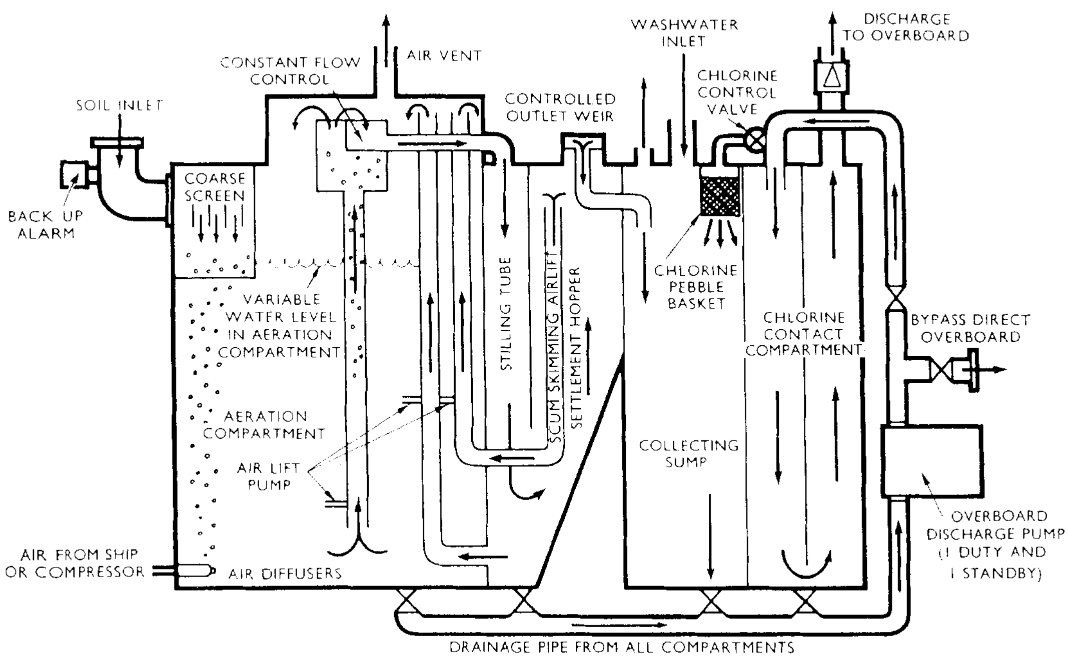

FIG. 2—PETERS MK II MARINE UNIT—DIAGRAMMATIC ARRANGEMENT

Description of the Mark II Marine Unit (See FIGS 1 and 2)

The sewage enters the treatment plant through a bar screen which traps any foreign bodies which unfortunately still find their way into flushing systems. The bar screen is washed by the contents of the aeration tank, thereby minimizing the task of cleaning the screen. The aeration tank contains the millions of aerobic micro-organisms called activated sludge. They feed on the sewage and are sustained by a large volume of air which is diffused into the tank. While so engaged, they give off carbon dioxide just as humans do, and the result is an odourless process. Liquid is transferred from the aeration stage by airlift to a settlement hopper and tank. The untreated solids and the replete bugs separate to the bottom while the treated effluent overflows to a collecting sump. Another airlift pumps the untreated solids and active sludge back into the aeration tank for further treatment, while a third airlift transfers back the scum and any floating solids from the top of the hopper. Wash waters from basins and showers are lead direct to the collecting sump to mix with the treated effluent and from there are pumped overboard through the chlorine contact tank. When the ship is in confined waters where chlorination is demanded, chlorine is added by the passage of some of the effluent through a chlorine pebble basket. When in the open sea, chlorination would not be required.

The discharge pump is operated by level-switches in the collecting sump and runs at approximately twenty-minute intervals so as to discharge a third of the contents of the contact tank on each cycle. Thus the chlorine contact time is approximately sixty minutes. The stand-by pump is also level-operated but is switched on by a higher level than that which operates the normal duty pump.

Air is supplied to the plant's own compressor, with a stand-by air supply available from the ship's LP air system. With a full ship's complement, the time clock settings for aeration air are usually two hours on and two hours off. The sludge return and surface skimmer airlifts are operated by an electrically controlled solenoid valve which allows them to function for only a few minutes every hour.

Safety Features and Indications

The local control unit contains amber warning lights labelled:

(*a*) Back Up—lights if a blockage of sewage occurs in the supply pipe

(*b*) High Level—lights when the liquid level is high enough to cause the stand-by pump to run

(*c*) Compressor Failed—lights when air supply fails.

Each of these failures will also operate a switch which gives a warning at the Ship Control Centre that something is wrong with the sewage plant.

Plant Operation

As the process uses natural organisms the plant requires a week or more depending on the load (i.e., food supply) to become fully functional. It is therefore usual to run it continuously in harbour and at sea, except for the chlorination stage which is used only when local regulations require. A substance called 'Acto Floc' may be added at 'start-up' to assist in the rapid development of an active sludge floc. Fluctuations of sewage input throughout the day do not cause any variation in plant performance, but as the well-being of the bugs depends on the supply of sufficient sewage and the correct amount of oxygen, any extended period of reduced input will upset the balance. This can be compensated by reducing the air supply, although there is a limit to the time that a very reduced input can be tolerated.

Loss of oxygen supply is of course a serious problem. One cannot be precise about timing due to the many parameters involved but the order of events is somewhat as follows:

(*a*) Biological treatment ceases after 4 to 6 hours

(*b*) Bacteria will die off during the next 4 hours

(*c*) All is not lost for, say, 36 hours, but time to get back to normal would be lengthy.

(*d*) Loss of air for a longer period is not to be contemplated, so get rid of the plant contents before this!

The micro-organisms consume most of the solid matter, but some particulate solids build up and must occasionally be pumped overboard. This is done when at sea, as the suspended solid level could be outside the legal level for a harbour even though the discharge would be inoffensive. In any case the temporary discolouration of the water round the ship would give the impression that a polluted discharge was being made.

Since air is supplied to the plant, it must be vented to atmosphere. The discharge gases are non-toxic, non-explosive and generally inoffensive, although when operating on salt water a smell is produced that is reminiscent of a wet ship's bathroom. The vents are therefore arranged so that they are not ingested by any other intake. The plant operates correctly when using either salt or fresh water, but there is a slight loss of performance during the change while the bacteria quickly adjust themselves to the new environment.

Conclusion

This article is not an exhaustive treatment of the subject of sewage and waste disposal; neither is it intended to give all the information that is provided in ship's drawings and manuals. The object has merely been to take some of the mystery out of the process and above all to show that there is no 'Euch' so long as the instructions are obeyed.